ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. [illegible] No. 21. 220 Broadway, New York, May 27, 1909.

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Hydraulic Construction of Large Embankments on the Chicago, Milwaukee & Puget Sound Ry.

The construction of the new line of the Chicago, Milwaukee & Puget Sound Ry. (which is the Pacific coast extension of the Chicago, Milwaukee & St. Paul Ry.) has included some heavy work in the Rocky Mountains, and among the special features of the work is the use of the hydraulic or sluicing system for building some very large embankments. This use of the hydraulic system in railway construction is not new, having been employed several years ago by the Canadian Pacific Ry. and the Northern Pacific Ry. (mainly, however, for the filling of high trestles). Some of the work on the new line, however, is not only of unusual extent, but involves interesting plant and methods. The pumping plant and the work on one of the banks were described in our issue of March 12, 1908.

The work described herewith was done under contract by the Smyth Contracting Co., and Mr. Sidney Smyth, President of the company, was in personal charge of the work. Mr. E. W. Cummings, consulting engineer for the company, designed the method of building the banks and also designed and constructed the hydraulic plant. Mr. E. J. Pearson is Chief Engineer of the Chicago, Milwaukee & Puget Sound Ry., and Mr. Geo. A. Kyle is Assistant Engineer. On the division which included the hydraulic embankments, Mr. James Wilson was Division Engineer; Mr. C. H. Byers, District Engineer; and Mr. H. J. Taylor, Resident Engineer. The offices of the contractors and the engineers are at Seattle, Wash. A general description of the work was furnished to us by Mr. Louis P. Zimmerman,* and we are indebted to Mr. Wilson and Mr. Cummings for additional information, together with drawings and photographs.

The work in question is on the west slope of the Cascade range, about 19 miles from the Snoqualmie Pass summit, and is in the canyon of the South Fork of the Snoqualmie River. It comprises four banks and four cuts aggregating 5,000 ft. in length (2,300 ft. for the banks and 2,700 ft. for the cuts). The largest bank (across Topographer's Gulch) is said to be the highest railway embankment in the world. The three large banks, which were built by sluicing, are as follows: Russian gulch (at the east end), Pearson's gulch, and Topographer's gulch. The fourth bank, at the west end, is 800 ft. long.

*302 Pioneer Building, Seattle, Wash.

but the grade was too low and the length too great for sluicing the material directly into place. The material was sluiced therefore into settling tanks or "sand bunkers." From these it was discharged into dump cars which hauled it out and dumped it on the fill.

A general plan and profile of the work are given in Figs. 2 and 4. The plan shows the location of the center line, the limits of cuts and banks, and the positions of the flumes and pumping plant, etc. The dimensions and approximate quantities of the three large banks are as follows: the west bank contained about 25,000 cu. yds., making a total of 860,000 cu. yds.

Name of gulch.	Length at grade line, ft.	Max. height, ft.	Max Roadbed width, ft.	Roadbed width, ft.	Quantities, cu. yds.
Russian	250	140	300	24	36,000
Pearson's	500	160	360	24	100,000
Topographer's	800	282	706	30	700,000

HYDRAULIC EXCAVATION AND SLUICING FOR CUT AND BANK AT TOPOGRAPHER'S GULCH; C., M. & P. S. RY.

(At the top are the hydraulic jets in the east cut and below these are the main and lateral flumes. The fine sand is delivered at the center of the bank and the coarser gravel at the sides. To the left of the jets is the end of the 24-in. steel pressure main from the pump, connecting with 16-in. wood stave pipes to the cuts. In the foreground, at the bottom, is the gravel flume from the west cut. Note the size of the trees.)

All the banks were built up with the material from the cuts at either end, working from both ends towards the center. The amount of work on the cuts depended entirely upon the formation of the hill, and not upon the amount of material to be moved. In Topographer's Gulch, the cost of the east cut was approximately eight times as much as that on the west side, there being three nozzles in use for 10 months at the former and two nozzles for four months at the latter. Yet the amount of material removed at the east side exceeded that from the west side by only 25,000 to 50,000 cu. yds.

The canyon is very winding, and its wall is broken by a series of lateral ravines with intervening spurs of ridges. Very heavy work is required to keep the grade within the maximum of 1.75% (Fig. 2). The ordinary method of building a railway through a region of this character, is to tunnel the hills and bridge over the intervening gulches. On these mountains, the soil is mainly glacial drift with a large proportion of sand and loose gravel, which makes it almost impossible to secure good foundations for bridges without excessive excavation. The sides of the gulches have so steep a slope that great retaining walls and protection sheds would have been necessary at the portals of tunnels. The snowfall is not excessive, and no landslides occur in this district.

The ridges are mostly of this loose glacial drift with very steep sides (the slopes ranging from 35 to 45%), and water is available in unlimited quantity in the river only a short distance away. Hydraulic sluicing was decided upon therefore as the most satisfactory method of making the cuts and building up the banks between the ridges. The contract for the four cuts and for the four banks was let early in 1907. Work was begun on the installation of the pumping plant and pipe lines in February, 1907, and sluicing was commenced on Nov. 15, 1907. The work was finished in January, 1909.

The general arrangement of the water supply and distribution systems is shown in Fig. 4. The water for sluicing is taken from the south fork of the Snoqualmie River at a point about half a mile above the first bank, where a dam has been built at a narrow rocky gorge. The

dam is of log crib construction, with rock filling, and is sheeted on the upstream side. It has a maximum height of 15 ft. and its crest is at an elevation of 1,128 ft. above sea level. From the dam, a flume extends for 5,300 ft. on a grade of 0.3% to a penstock box at the edge of Topographer's Gulch, the water level in the box being

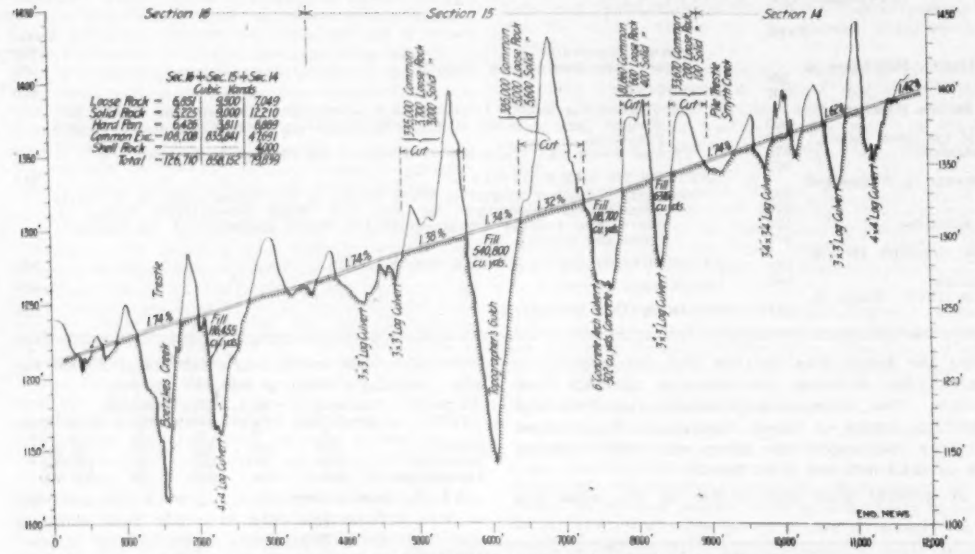


FIG. 2. PROFILE OF LINE HAVING HYDRAULIC BANKS AND CUTS.

at an elevation of 1,112 ft. The connection with the reservoir is made on the north bank of the river, and the flume is carried across the river (just below the dam) by a truss bridge of 60-ft. span (Fig. 4). The flume had one trestle 600 ft. long, and another 950 ft. long, the latter with a maximum height of 56 ft.

The flume was V-shaped, as shown in Fig. 3, its cross-section being formed by two sides of an equilateral triangle, each 6 ft. wide. The sides were made of two thicknesses of 1-in. fir lumber in widths of 8, 10 and 12 ins., laid so that the layers broke joints. The flume was supported on sills 4 ft. apart and was braced on both sides with 2 × 6-in. pieces. These also were spaced 4 ft. apart, and were toe-nailed to the sills and to the cross timbers on the sides of the flume. The flume of V-section was adopted as being more easily built, curved, and kept watertight than a rectangular flume.

From the penstock box, a pressure pipe was led to a pumping plant on the bank of the river. This was a 38-in. wood stave pipe having a fall of 398 ft. in about 800 ft. to the pump. An overflow flume was also led from the penstock box to the river, as shown. The pumping plant was set upon a concrete foundation and consisted of a 16-in. four-stage Worthington turbine pump, directly connected to four impulse water wheels in parallel on the same shaft. A steel branch or by-pass diverted part of the water from the penstock to the pump suction or intake. The water supply system, including the dams, flumes, pumping plant, etc., involved an expenditure of about $40,000.

From the delivery side of the pump, a 24-in. steel pipe about 1,450 ft. in length was carried up the slope to a three-way box or junction at an elevation of about 600 ft. above the pump. The gage pressure at the lower end of this pipe was 340 lbs. per sq. in. From the junction box, three lines of 16-in. wood stave pipe were led to the different cuts, to serve the excavating nozzles. The longest distributing branch was a 16-in. pipe half a mile in length. These branches were run as nearly level as possible in skirting them around the hills. For the excavating and sluicing jets, 6-in. and 4-in. rubber hose and plain nozzles with an effective diameter from 1⅛ ins. to 3½ ins. were used in all the work. The pressure at the nozzles varied from 40 to 80 lbs. per sq. in., depending on the kind and location of the material moved. A plain ring bushing was used in the nozzles to choke the size of the stream and regulate the pressure. There were 10 nozzles used in all; four of these were used in Topographer's Gulch, four on the east side and two on the west side.

All the material used on the work, including the Worthington turbine pump weighing 22½ tons, had to be hauled a distance of 2½ miles by wagon and team, from the end of the railway spur at the Weeks saw mill. Much material had to be taken up the hill from time to time from the wagon road, and it was impossible to haul it by teams. A 36-in. Risdon water wheel was installed at the top of the hill, about ¼-mile from the wagon road. This was connected to the 16-in. pipe line with a 16 × 16 × 6-in. T-connection and valve, and the wheel was directly connected to a 60-HP. hoisting engine. The drums and levers of the engine were used to control the movements in the usual way. A ⅞-in. and ⅝-in. steel cable were used to haul the material up the hill. At night, the water wheel was disconnected from the hoisting engine, and was belted to a direct-current dynamo used to supply the current for the arc lights distributed over the work for lighting the work at night.

The foundation and setting for the water wheel and pumps, the intake, discharge and tail race were all built of concrete. Just above the concrete bed of the pumping plant, the penstock made an angle of about 30° in coming into the vertical intake of the turbine pump. To strengthen this portion of the pipe, a frame 6 ft. high (of fir planks 2 × 12 ins.) was built around it and filled with gravel. This added additional weight and stability to the wheel foundation and supported the lower end of the penstock.

The lower end of the 38-in. stave pipe of the penstock was subjected to what is said to have been probably the greatest pressure ever used on wood pipe work, 175 lbs. per sq. in. This pipe was made of staves cut to the radius of the pipe from 2 × 6-in. planks, 12 to 20 ft. long. The staves were bound with ½-in. steel bands of about 60,000 lbs. tensile strength. The distance between the bands varied with the pressure to which the pipe was subjected. At the lower end of the penstock the bands were spaced as close together as it was possible to put them, and the staves carried the pressure without any signs of deterioration. The wood pipe was laid upon the ground and not covered. It followed the contour of the surface, and was anchored as securely as possible by means of steel cables passed around the pipe and fastened to trees and stumps.

The general plan in the hydraulic sluicing work for the bank across Topographer's Gulch, provided for segregation of the materials. This was in view of the large amount of sand and fine glacial drift in this section of the mountains. Three principal constituents were found in the soil: gravel, sand and rock, with a very small amount of glacial loam. The soft, loose condition of the glacial drift in Topographer's Gulch, the large percentage of sand an[illegible]ose gravel, and the steep grade of the botto[illegible] the gulch (about 33%), made it necessary to [illegible]gregate the materials for the fill, and this wa[illegible]one by the use of settling tanks or bunkers. [illegible]The coarse gravel and rock were thrown on[illegible] down-hill side of the slope, the sand was [illegible] inside the outer wall of gravel, and the sluic[illegible] water was drawn off and discharged outside [illegible] fill. This method of working necessitated th[illegible]se of settling tanks or sand bunkers, for [illegible] character of the soil is such that if a large am[illegible]t of water were run over it a large amount [illegible] the loose gravel would wash down the gulch. While this method of segregating the material [illegible]s used at the start, later on in the work all g[illegible]es of material were deposited together in the bank.

The view on the front page shows [illegible]e work at Topographer's Gulch. At the top (in [illegible]e cut) are the excavating jets, with the main and lateral flumes extending along the site of the bank. At the middle, near the bottom, may be noticed the finer material which was washed into place to form the center or core of the bank. The general plan employed was as follows: Starting at the point where the sluiced material was cut out by the water jets, flash boards were placed to direct the material into a wooden flume. This flume led to the sand settling tanks, from which three flumes led out; one carried water outside the work (so as not to erode the bank), one carried gravel, and one carried sand to the bank. The grade of the flumes at first was 45%; as the cut increased and the bank was built up, the grade gradually lowered to 10%, which was the lowest grade used. A short section was laid with a grade of 5%, but the only way in which material could be carried through it was by placing streams under heavy pressure 50 ft. apart to drive the material along. In starting the cut,

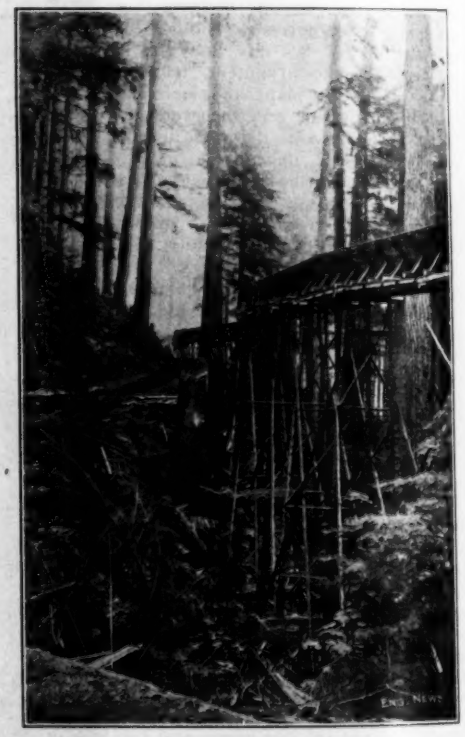


Fig. 3. V-Shaped Flume for Supplying Water-Power Pumping Plant for Hydraulic Excavation (Section 6 x 6 Ft.).

the flume was built out half way across the gulch and the material taken from the lowest part of the cut just above the grade line. As the fill was built up the grade was decreased, the material being dumped closer in and being taken from the higher elevations of the cut. A small amount of excavating in the center of the cuts was done with a steam shovel.

Various grades for the flumes were used during the work (as noted above), and a grade of 15% was found to be the most economical. At this grade the rock (of which there was a large pro-

portion) ... slide from the flume continually; with a ... grade, the flow was slower and more w... was needed to carry the material along. ... steeper grade, the rocky materials ... such momentum that they rolled and bou... down the flume in a manner extremely ...gerous to the men, and very hard on the s... and bottom of the flume itself.

The fl... construction is shown in Fig. 5. The flum... were 24 ins. wide inside and 24 ins. high, bu... of 2 × 12-in. plank, set edge to edge, with the ... nailed on the outside of the bottom. Br... 2 × 6 ins., 4 ft. apart, at an angle of 45°, ... toe-nailed to the 2 × 6-in. plank sills. U... pieces 2 × 6 ins., 4 ft. apart, were

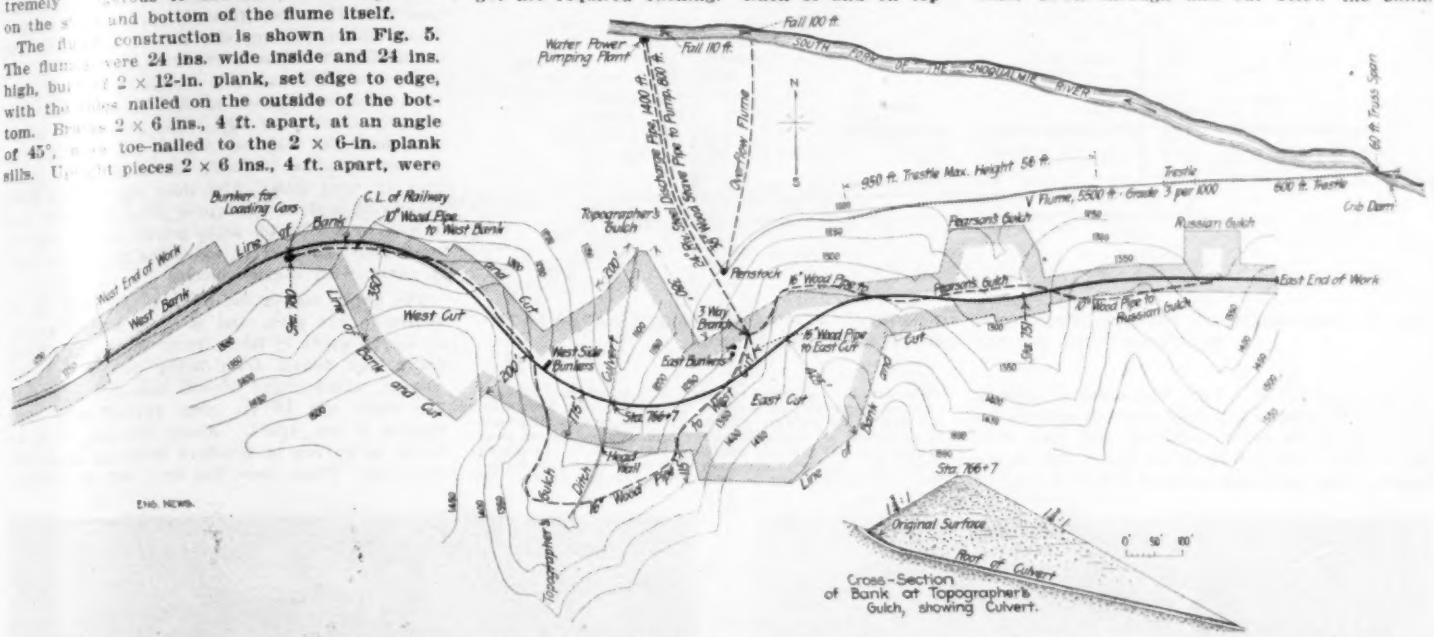


FIG. 4. PLAN OF BANKS AND CUTS FORMED BY HYDRAULIC EXCAVATION AND SLUICING, AND ARRANGEMENT OF THE WATER SUPPLY SYSTEM FOR THE HYDRAULIC WORK; CHICAGO, MILWAUKEE & PUGET SOUND RY.

used to hold the sides of the flume in place. The flume had a walkway on one side for the use of the men. The flumes were carried on ordinary timber trestles, some of which were 50 ft. in height. These were all built of green timber cut on the mountains. As the flume carried a large percentage of rock and coarse gravel, the bottom was paved with 6 × 12-in. wood blocks 4 ins. thick, set on end and toe-nailed. The blocks were from butt cuts of live, green, yellow fir of a uniform texture, and packed closely together to get an even wear. They eliminated uneven spots almost entirely. Fir planks 2 × 6 ins. were nailed on both sides of the flume just above the blocks to prevent wear on the sides of the flume, and to hold the paving blocks in place on the bottom.

The settling tanks or sand bunkers were arranged as shown in Fig. 6. Those located at the end of the first flume and connecting to the distributing lines out on the work, were 14 ft. square and 12 ft. high, built of 3 × 12-in. fir planks set edge to edge and calked with oakum to be practically watertight. These bunkers were used to precipitate the sand and run off the clear water down the outside of the bank. A sand flume 2 ft. square was attached to the tank, having a steel gate and lever operating handle. Only enough water was admitted to the sand flume to carry the sand out readily. The sand flume was paved with 2-in. blocks, toe-nailed as in the two other flumes. Two guard rails 2 × 6 ins. were placed just above the blocks to hold them in place and take the wear from the sides of the flume. About 1 ft. from the top of the tank a 12 × 12-in. water waste flume led down over the side of the bank with a slope of about 40%. In Fig. 8 may be seen some of these waste flumes extending down the face of the new bank.

Above the bunkers a screen or grizzly was built in the bottom of the main flume. Through this the water and sand drained into the settling tanks, while the coarser gravel and rock passed over and down the gravel flume. The grizzly was 12 ft. long with 6-in. openings lengthwise of the flume.

The bank at Topographer's Gulch was built up on a slope of 1 on 1¼ (Fig. 1), varying somewhat with the nature of the material and the amount of water used to move it. Starting at the lower bottom side of the fill, brush dikes were built up as shown in Fig. 7. Posts 3 to 5 ft. long were driven so as to leave about 2 ft. of the post above the surface in a line where the dike was to be built. The posts were spaced about 8 ft. apart. Behind this framework some gravel and sand was washed up with a hose to get the required backing. Back of and on top of this, green brush with the butt ends resting on the upper part of the framework was piled to a sufficient depth to hold the material behind it.

The amount of brush used depended, of course, upon the fluidity of the material behind it. It was found that by placing the tops or ends of the limbs and trees pointing towards the inside of the dike, a much better and more effective dike was obtainable with the same amount of material. This was due to the fact that when pointed in and down, the mud would bend the branches back and so make a firm solid mat of twigs. Turned the other way, the mud would slide over the brush very easily. On an average the dikes were built about 2 ft. high and spaced about 3½ ft. apart, giving a slope of 1 on 1¾. This is shown in Figs. 8 and 9.

In building up the material behind the dikes, due to the excessive looseness of the earth, it was impossible to allow the sluiced water to run to waste over the slope of the bank, as it would have washed away the filling. In the hydraulic

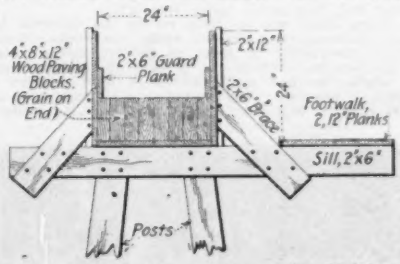


Fig. 5. Construction of Flumes for Sluicing Material to the Bank.

regrading work at Seattle, Wash.,* the material is run on the mud lines and allowed to pile up and flow off, which sluiced material will do with a slope of about 1 on 4. Spillways are provided and the water escaping carries with it a considerable amount of material in suspension which is deposited farther out on the tide flats. This is permissible in that work as it is not wasted, and the fill on the tide flats covers a large area to a depth of only a few feet.

On the railway work, however, in filling up behind the dikes, the material was washed toward the outer edge of the fill with a hose, and as high as possible over it, usually a foot or two. This method left the water standing on the top of the fill usually from 20 to 30 ft. back from the outer edge. To dispose of this, "chimneys" and box drains were used to carry the water down through and out below the bank. These "chimneys" are shown in Fig. 7. They are vertical flumes 16 × 28 ins. in section, made of 2 × 12-in. fir planks. A connection with a slope of about 2% is built from the outside of the embankment, in and up as far as possible, and then another vertical connection is put in and led through the fill to the surface. When by stepping back, the outer edge of the bank comes to the top of the vertical chimney, another 2% connection drain is built in and back. The upper side of this drain is built of 2 × 6-in. planks placed crosswise for greater strength to support the bank above it. Above the surface, one side of the "chimney" is left open and as the

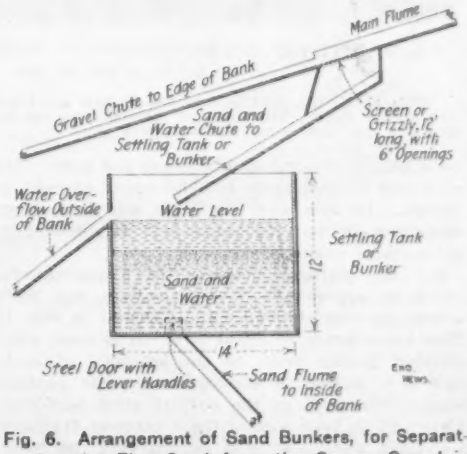

Main Flume
Gravel Chute to Edge of Bank
Sand and Water Chute to Settling Tank or Bunker
Screen or Grizzly, 12' long, with 6" Openings
Water Over-Flow Outside of Bank
Water Level
Settling Tank or Bunker
Sand and Water
12'
14'
Steel Door with Lever Handles
Sand Flume to Inside of Bank

Fig. 6. Arrangement of Sand Bunkers, for Separating the Fine Sand from the Coarse Gravel in the Sluiced Material.

bank fills, cross timbers are nailed on so that the water flows over and into the chimney. A screen of ordinary wire netting was used to keep out refuse from the flume. Fig. 10 shows one of these chimneys with screen in place. When this system was used, the bunkers were omitted and all the water went upon the bank.

Where the top surface of the bank is mud or clay, the water will flow over the top and collect around the drain chimneys and run away through them. Where there happen to be pockets of gravel or rock, the water will sink in and flow along these strata until it comes to the outside

*Engineering News, Nov. 12, 1908.

of the embankment, where it breaks out sometimes 150 ft. below the surface of the fill. To prevent these breaks from enlarging and washing away the side of the fill, a drain or lead-off pipe was put in. This was done by making a bed of fir boughs and tops close up against the bank where the break occurred, and then driving a pipe into the bank at the point of the break. This pipe was dammed up with clay on both sides and covered with brush and poles. The pipe was carried down and the water allowed to escape. In this way the bank was kept from sloughing off and the water was disposed of in the natural drainage channel.

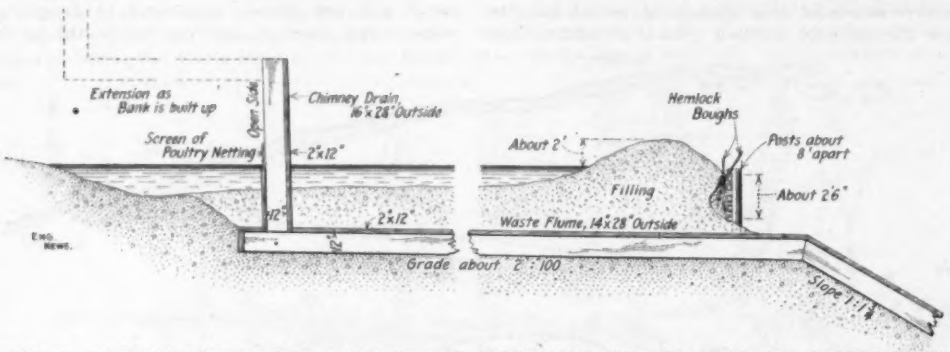


FIG. 7. ARRANGEMENT OF BOX DRAINS AND "CHIMNEYS" FOR CARRYING OFF WATER FROM SETTLING POOL ON TOP OF HYDRAULIC-FILL BANK.

For the natural drainage of Topographer's Gulch an egg-shaped concrete culvert was built across the site of the bank, as shown in Fig. 1. This has a grade of about 35%. It is lined with vitrified paving brick on the bottom. At each end is a paving of rip-rap to provide against scour. The area of the culvert gives sufficient waterway to take care of the maximum drainage and flood waters without endangering the bank by pressure on the upper side. The culvert was braced on the inside by temporary timber supports during the construction of the lower part of the bank. These timbers were not allowed to be removed from any part of the culvert until that part had a covering of sluiced material (well compacted and free from water) to a depth of at least 2 ft. over the crown of the culvert.

The details of this culvert are shown in Fig. 11, together with the aprons, the end cut-off walls, the forms, and the temporary interior bracing above mentioned. A similar culvert was built in Pearson's Gulch. The approximate quantities are as follows: concrete per lin. ft., 1.36 cu. yds.; concrete in end walls, 26.4 cu. yds.; rip-rap at ends, 18 cu. yds. The general specifications for culverts are as follows:

The bed under the culvert must be finished to proper level and grade and thoroughly rammed in order to prevent (as far as possible) settlement under weight of embankment. A slight camber will be given to guard against formation of pockets by settlement. Generally the fall of the culvert will be as steep as the difference in elevation of inlet and outlet will admit. In no case should the fall average less than 1 in. in 6 ft. In places where the nature of the ground is such that any settlement is liable to occur, the culvert should be built in sections 8 or 10 ft. long, separated with a heavy layer of tarred felt; the joints to be vertical.

The filling shall not be done before the concrete has set, the minimum time allowed being two weeks. Tamp the earth thoroughly on sides of culvert, using water, when practicable. Where the culvert crosses the track at an angle, the end walls should be built parallel to the track, if possible. The ingredients for concrete, except for inverts, will consist of 1 part Portland cement, 3 parts of clean sharp sand, and 6 parts of broken stone or gravel, by bulk. The ingredients for concrete for inverts will consist of 1:3:5 parts.

The quantity and arrangement of rip-rap at ends may be modified by the division engineer to suit the varying conditions of the ground. The depth of foundation walls shall be changed wherever necessary to meet conditions as they are found.

A special feature of the culvert at Topographer's Gulch is that from its upper end a wooden flume is carried up the bed of the gulch for about 500 ft. This is shown in Fig. 12. It has grades of 17% and 20% at the upper end, and then falls on a grade of 90%, entering the culvert by a grade of 50%. The changes in grade are made by vertical curves, as shown. The bottom consists of three layers of 2-in. plank laid on mud sills. The sides are of 3 × 6-in. planks (6 × 6 at the upper end), laid flat, and spiked to 8 × 12-in. posts placed at the ends of each sill. To prevent excessive wear, the floor is paved with wooden blocks.

The upper end of the flume is widened out, as shown in the plan, and is fitted with a grizzly or screen made of 60-lb. rails; this is to prevent rocks and debris from being carried into the culvert, which might become damaged or choked. The rails are 18 ft. long, spaced with their flanges 4 ins. apart. Above the screen is an apron or paving of boulders weighing about 150 lbs. each. These were laid on a bed of concrete,

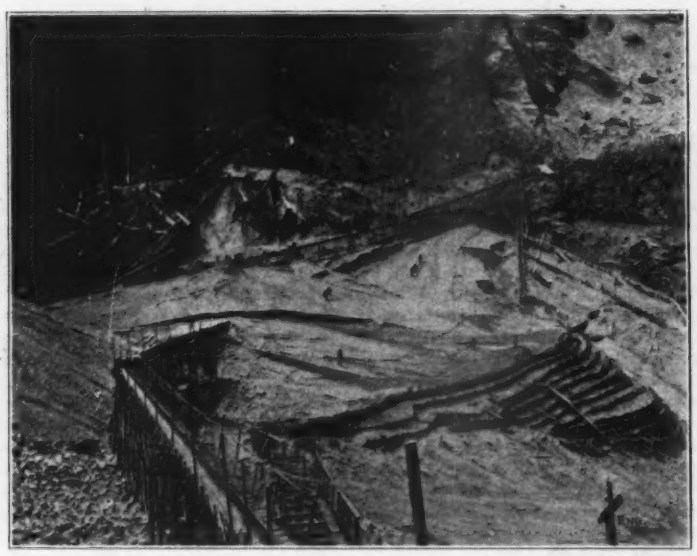


FIG. 8. HYDRAULIC EMBANKMENT AT TOPOGRAPHER'S GULCH; C., M. & ST. P. RY.

(This shows the settling pool and the pole and brush dams for building up the face of the slope. The flume at the right, on the far side of the bank, comes from the sand bunker or separating tank.)

FIG. 9. BRUSH AND POLE DIKES FOR BUILDING UP THE SLOPE OF THE BANK.

Fig. 10. Vertical Drain or "Chimney" for Draining Water from the Settling Pool Through the Bank.

and the voids were filled with a 2:1 grout of cement and sand.

The general character of the work at the other two hydraulic-filled banks was similar to that above described in regard to the bank at Topographer's Gulch. In each of these two cases, however (at Pearson's and Russian gulches), the bottom of the gulch was of hardpan, the slope was flat, and the glacial drift was very much harder than in Topographer's Gulch. This made it unnecessary to use sand settling or separating tanks for the work on these two banks. At the West or fourth bank (as already noted), the sluiced material was delivered to dump cars and not sluiced directly into place. The work at the four gulches was carried on more or less simultaneously, as conditions warranted. About 12,000,000 gals. of water per 24 hours were used throughout the year.

STEAM PROPULSION BY TUGS has been adopted by the German Government for the Rhine-Weser canal. The decision is said to have been influenced by experience with electric traction on the Furow canal, where electric traction was introduced in 1898, and the Teltow canal, where electricity was introduced three years ago. The objections to electricity are the heavy cost of installation and operation, and the obstruction of the canal banks by the rail tracks and trolley lines.

Flexible Staybolts for Locomotive Boilers.*

We have to consider the cost of applying flexible bolts in comparison with the cost of applying rigid or solid staybolts. I find in computing the cost of both the flexible staybolts and rigid staybolts, a difference of something like 50%, which cost has to be credited to the applying of the flexible staybolts. Is the cost commensurate with the service and excess cost of this bolt over the rigid or solid staybolt? I maintain that it is.

Now let us consider the flexible staybolt at a cost of 50% more for application to a locomotive boiler. We shipped one of our engines for overhauling. The boiler was sent to the boiler shop for a new firebox, with instructions to make a full installation of flexible staybolts; that is, back head, throat sheet, and both side sheets up to the seams of wagon top. This engine has been in service now for over 2 years and has not had one broken staybolt removed. This looks pretty good for the flexible staybolts, as engines of this same type only run from 60 to 90 days before more or less of the solid staybolts have to be renewed.

When we figure the cost of maintenance of locomotive boilers in service and compare the general cost of the solid staybolt against the first cost of the flexible staybolt, we can readily see, from a cost standpoint, that the excess cost of the application of the flexible staybolts, everything considered, has the best of the rigid staybolts.

In the application of flexible staybolts, I would suggest always a full installation of these bolts. When these bolts are applied spasmodically, or in what is considered the breaking zones, the rigid bolts next to the flexible bolts later on break or fracture. For this reason I believe it would be wise to always make a full installation, keeping before us always the loss to the company of from $600 to $700 per day for every day the engine is out of service.

From causes such as bad water, or possibly a poor sheet of steel, it was necessary to remove a firebox from one of our engines to which I applied a new firebox about 2½ years ago. This engine had a full installation of flexible staybolts, and the man who removed this firebox advised me that he failed to find a broken flexible staybolt in this engine.

When the firebox is placed in the boiler, mud ring fitted, firebox sheet faired up, the first thing I do is to map out the zones for solid staybolts, then I have these holes tapped out and staybolts run in. Thus I secure the firebox sheets from the danger of pulling in as each successive flexible staybolt is applied. It only requires a very little strain on each bolt put in to draw the side sheets of a firebox until in the center of the side sheet, you will (by using a straight edge) find your sheet drawn in from ½ to ⅝-in. Where your bolts are cut to length, this becomes a serious feature in the application of flexible staybolts.

Having had this trouble, I have instituted the above method to overcome this difficulty and it works very nicely. When all flexible staybolts are in the several zones, I remove the solid bolts that I have put in to stay the firebox sheets. Then drill, ream and tap out and apply the balance of the flexible bolts, this completing the full installation of flexible staybolts in this engine.

For testing flexible staybolts, I recommend a hammer test under air pressure, when it is possible to get a pressure of air from 125 to 150 lbs. Where the bolt is broken, this, in a measure, separates the parts and the broken bolts are easily detected. However, it will be somewhat more difficult to detect a fractured bolt, but where the inspector is a careful, painstaking man, this will soon be overcome as he will, in connection with this method, learn to detect the difference in sound of the broken and fractured bolts.

*Abstract of a committee report presented at the annual meeting of the International Master Boiler Makers' Association, held at Louisville, Ky., in April, 1909.

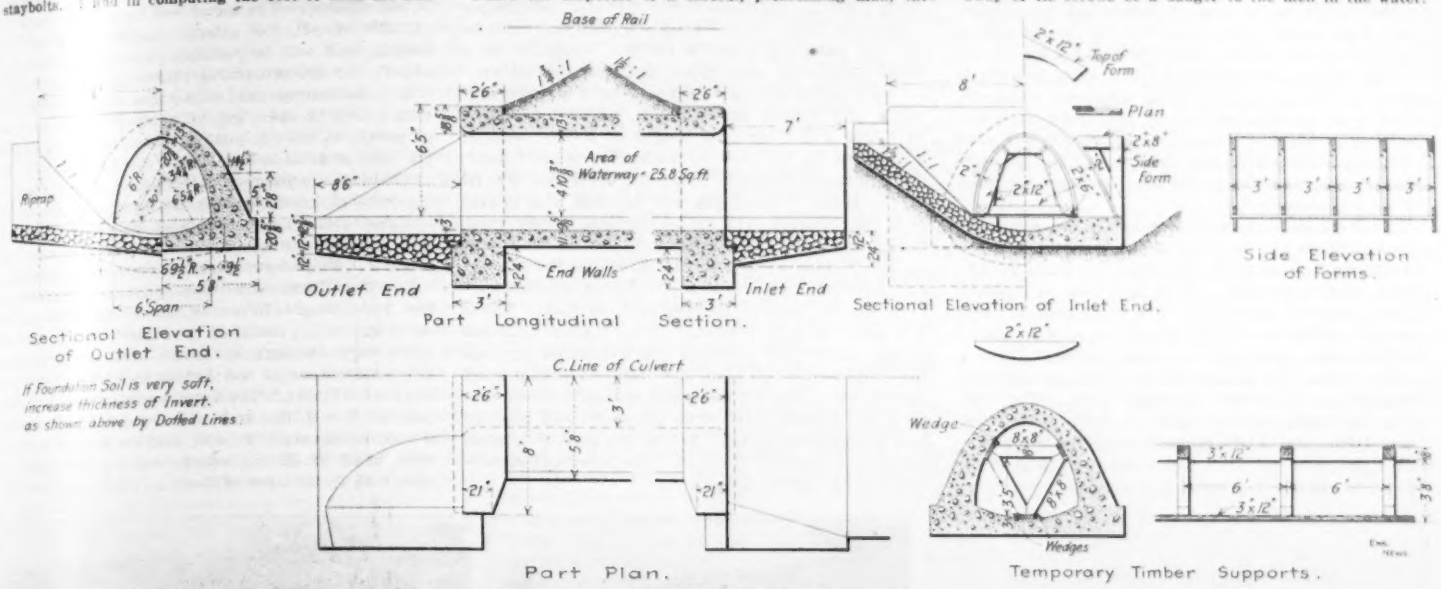


FIG. 11. CONCRETE CULVERTS UNDER HYDRAULIC EMBANKMENTS; CHICAGO, MILWAUKEE & PUGET SOUND RY.

MOTOR LIFEBOATS are being introduced in England by the National Lifeboat Institution. No steam lifeboats have been built by the Institution since 1901, owing to the promising development of the internal-combustion engine for marine work. The motor must be enclosed in a perfectly watertight casing, the engine must require practically no attention when running, and the carbureter must be so designed as to give a regular and proper mixture even when the boat has a heavy list to one side. In case of a self-righting boat capsizing, the engine must be stopped automatically, so that the boat will not run away or its screws be a danger to the men in the water. It is also necessary that the engine and apparatus must not reduce the rowing and sailing qualities or interfere with the balance of a self-righting boat. Two-cylinder engines were first used, but are being replaced with four-cylinder engines. A boat 43 ft. long and 12½ ft. beam has a Blake engine developing 40 brake-HP. at 550 r. p. m. A boat 42 × 11 ft. has a Tylor engine of 30 HP. at 900 r. p. m., and a boat 37 × 9½ ft. has a Thornycroft engine of 24 HP. at 1,000 r. p. m. All these are four-cylinder engines. The engines are of special advantage to assist when sailing, enabling the boats to work against the wind.

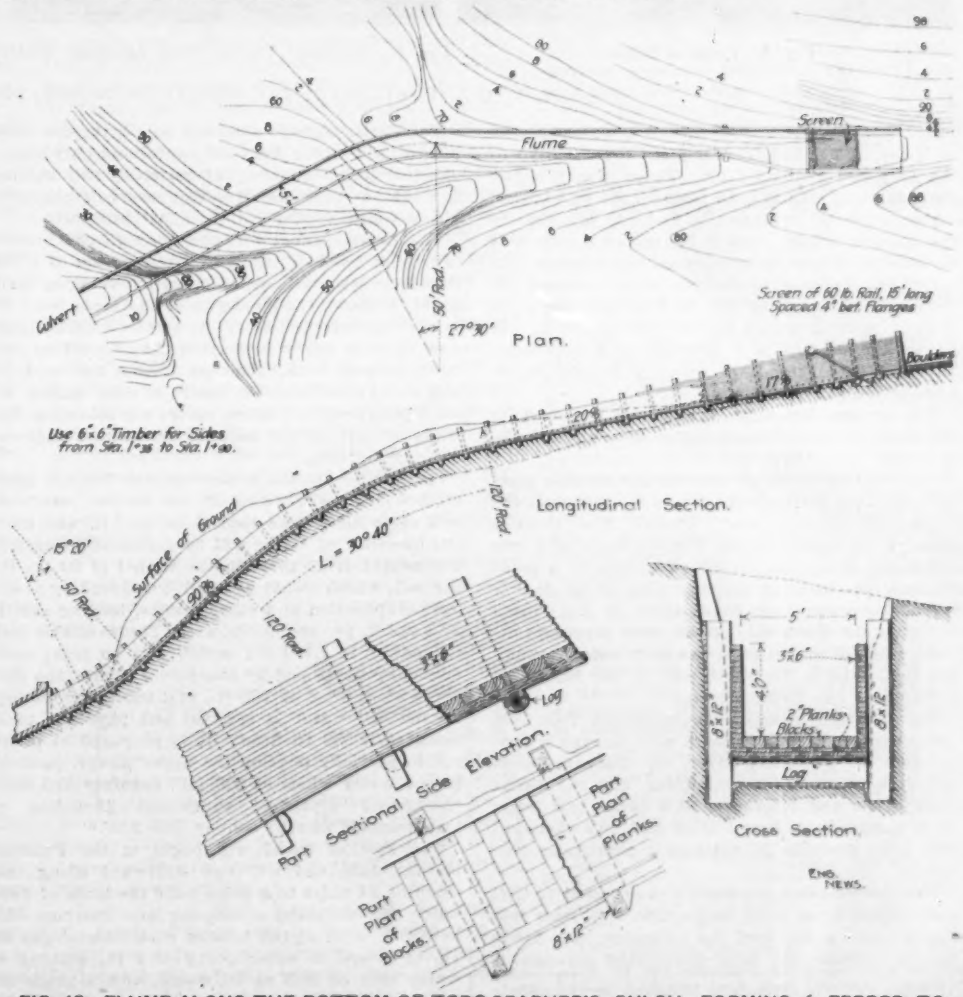


FIG. 12. FLUME ALONG THE BOTTOM OF TOPOGRAPHER'S GULCH, FORMING A FEEDER TO THE CONCRETE CULVERT THROUGH THE BANK.

Proposed Construction Work of the Porto Rico Irrigation Service.

By B. M. HALL.*

The following is a brief statement concerning the South Coast Irrigation Project in the Island of Porto Rico, which was provided for by an act of the General Assembly of Porto Rico, known as the General Irrigation Law, approved Sept. 18, 1908, and by another act of the same date approving a 4% bond issue of $3,000,000 for said purpose; since which date the bonds have all been sold at par, and the funds are available for construction work.

The land to be irrigated is along the Southern coastal plain of the Island of Porto Rico, between Patillas and Juana Diaz, in latitude 18° north of the equator. It is proposed to irrigate 22,000 acres of land that is not at present irrigated, in addition to such land as is now irrigated by diversions from the streams that will form a part of the water-supply for the proposed project. The principal product is sugar cane. The distance by water transportation is 1,400 miles from New York, and 1,548 miles from New Orleans.

Freights are low, and there are various landing points along the Southern coast, close to the proposed works. There is a railroad along the coastal plain, and a line from a point near Arroyo to the proposed Patillas Dam. There is also a fine macadamized wagon road from Ponce to Patillas.

The proposed irrigation is to be in addition to the natural rainfall, and is figured on a duty of 4 ft. net and 5 ft. gross (measured in streams). The estimated value of irrigation is an annual increase in the crop of $75 to $150 per acre, the greater part of which will be net profit, as the lands are already in cultivation and the sugar factories (Centrals) have capacity largely in excess of present crop production.

The general irrigation system, as proposed, is composed of two divisions; the Eastern and the Western.

The Eastern division includes the Patillas storage dam, the Patillas canal and laterals, and the Carite storage dam and tunnel. The Patillas canal is to begin at the Patillas dam, and run westward along the foothills 24 miles to a point opposite the town of Salinas. The Carite dam is intended to store the headwaters of La Plata River on the north side of the main mountain divide, and the tunnel to divert said water through the mountain to the south side of the Island, as a feeder to the Patillas canal.

The Western division comprises the Toro Negro diversion, from the north side through a tunnel into the Jacaguas River, the Guayabal storage dam on the Jacaguas River, and the Juana Diaz canal and laterals. This canal will begin at a point above Juana Diaz and run eastward along the foothills 24 miles to a point near Salinas.

The two systems combined are expected to irrigate 22,000 acres from water that now runs into the sea and is not used for irrigation. As floods on the streams are well distributed throughout the year, a given reservoir capacity is four or five times as effective as in most other regions.

The water issuing from the Carite and Toro Negro tunnels will have precipitous falls of more than 1,000 ft., and over 3,000 HP. can be cheaply developed from them. Cheap power can thus be sold to pumping stations for the irrigation of a large additional area from underground water.

The Patillas storage dam will be a structure of earth and gravel 122 ft. high, with slopes of 3 to 1 and 2 to 1 up to a height of 100 ft., and of 2 to 1 and 1½ to 1 for the remainder of the height, the thickness being 20 ft. at the crest and 600 ft. at the base. The slopes will be rock and gravel and the interior will be impervious sandy clay, well compacted. In round numbers the dam will be 500 ft. long at a point 15 ft. above the bottom and 1,000 ft. long at the top. The up-stream surface will be heavily riprapped with rock. There will be a concrete core wall at the bottom, founded in the impervious bedrock and extending up into the impervious clay of the dam to make good connection. The outlet tunnel and gate shaft will be in solid rock, lined with concrete, and contain two independent gates. There will also be a large spillway at the 107-ft. level. The reservoir capacity will be 12,000 acre-ft.

The Carite storage dam will be a structure similar to the Patillas dam, but containing only about one-fourth the quantity of material, and having a height of only 100 ft. The reservoir capacity above tunnel outlet will be 9,500 acre-ft.

The Carite tunnel will run through the mountain from north to south at an elevation of 1,736 ft. above sea level, which elevation is more than 1,600 ft. above the elevation of the main body of land to be irrigated by it. It will be 3,000 ft. long and there is every indication that it will be entirely in solid rock. The net section will be 4 ft. × 6 ft. It will not be concrete lined except at such points as may be necessary for retaining the walls or roof, or for keeping the section approximately uniform.

Systematic stream measurements for the past sixteen months show that the Carite reservoir will store all waters that come into it, and that the quantity of water will be sufficient to supply a constant draft through the tunnel of 30 cu. ft. per sec., which would be slightly reduced by seepage, evaporation and other wastes, leaving safely 27.5 cu. ft. per sec. for power. The available fall for power is 1,100 ft., which can be most economically developed by two power plants, the upper with a head of 750 ft., and the lower taking up the tail water in a canal and pipe line to a plant with 350 ft. head. It is proposed at present to partially develop the upper power, putting in one water wheel of 600 HP. capacity and corresponding electrical equipment, including a transmission line to convey 360 KW.

The Patillas canal will begin at the Patillas storage dam and will run westward along the foothills 24 miles to a point near the town of Salinas. The standard section for level cuttings will be 8.2 ft. wide at the bottom with side slopes of 1½ to 1, and a water depth of 4 ft., making a water area of 56.8 sq. ft., which, with a grade of 0.6 ft. per 1,000 ft., will give a capacity of 150 cu. ft. per sec. In this section th… will be 20 ft. wide. For thorou… ground and for steep hill sides … changed to suit condition, but th… is maintained. The canal will ha… of 150 sec.-ft. for about three … length, and will be reduced to a … sec.-ft. for the remaining fourth …

It is estimated that this canal … excavation in open cut of about … of earth, 53,000 cu. yds. of loose … cu. yds. of solid rock. There will … of tunnels in solid rock, 2,000 lin. ft… concrete siphons, besides the nec… bridges, etc. There will also be … and concrete lining on such secti… quire it. The above quantities are …

The Toro Negro diversion will tak… the Toro Negro River on the nor… main mountain chain of the Island, … southward through a tunnel 3,200 … the headwaters of the Jacaguas River above the town of Villalba. The tunnel will h… tion of 5 × 7 ft., and will not be … where necessary. It will operate … sure head of 32 ft., which will be … about 45 ft. at time of flood. Just …

The Guayabal storage dam and reservoir is to be located on the Jacaguas River, about two miles north of the town of Juana Diaz. It will be similar to the Patillas, but will contain only a little more than one-half the quantity of material.

The Juana Diaz, or Jacaguas canal, will take water from the Jacaguas and Toro Negro rivers. It will begin at the Guayabal dam and run eastward along the foothills 24 miles to a point near the town of Salinas. The approximate quantities are estimated as follows: 570,000 cu. yds. of earth, 42,000 cu. yds. of loose rock, and 34,000 cu. yds. of solid rock; 800 lin. ft. of tunnel, 8,000 cu. yds. of reinforced concrete. There will be a concrete dam across the Coamo River, 54 ft. high, and a conduit in the dam for conveying the canal water across the Coamo River.

In the construction of the Patillas, Carite and Guayabal dams it is estimated that the impervious sandy clay forming the interior can be more cheaply placed and compacted by the hydraulic fill process than by ordinary methods, and that this process properly applied will insure greater density and imperviousness. The water supply is ample in every case, but at the sites of Patillas and Guayabal dams the greater portion of the material is below sluice grade and will have to be elevated.

Plans and specifications for the Patillas canal are completed, and are called for to be opened June 14, 1909. As soon as construction has been begun on the Patillas canal, other features will be taken up for construction as promptly as it appears to be advisable, beginning with the Carite dam and tunnel and water-power, the Juana Diaz canal

*Chief Engineer, Porto Rico Irrigation Service, Guayama, P. R.

Fig. 1. Catalina Canal.

Fig. 2. Diversion Flume, from Jacaguas River.

Fig. 3. Flume on Irrigation Canal from Salinas River.

FIGS. 1 TO 3. PORTIONS OF OLD IRRIGATION WORKS, PORTO RICO.

the T[illegible] diversion and the Guayabal dam. It is [illegible] that bidders shall have every opportu[illegible] obtain a full knowledge of the work to be [illegible] and the conditions that will be met with. [illegible]its are being excavated to grade all along [illegible]anal lines, and to bedrock at the dam-sites, [illegible] everything else is being done that will give all [illegible] information possible. Before making a bid, [illegible] bidder will be required to visit and examine the site of the proposed work, or to be thoroughly acquainted with the same by sending a duly [illegible] credited agent for that purpose.

It is believed that a full and complete investigation will convince any prospective bidder that work can be done as cheaply in Southern Porto Rico as anywhere else in the United States. The climate is mild and healthful, and it is totally free from the disadvantages generally met with in the tropics. As compared with the Eastern United States, the summers are cooler and the winters are like spring and autumn. The work season is all the year round, with no snow or ice, and with no more delay from rainy weather than in the most favored regions of the Eastern States. Common labor is more plentiful here than anywhere else in the United States, and only requires systematic training to become efficient. The Island is a part of the United States, and the people are loyal, courteous and law abiding.

MONTHLY FLOW OF STREAMS IN ACRE-FEET AVAILABLE FOR NEW IRRIGATION.

Month.	Patillas.	Carite.	Toro Negro.	Doña Juana.	Floods of Jacaguas going to sea.
1907.					
October....	3,971	1,681	*	*	*
November..	2,178	937	737	240	7,000
December..	3,617	1,399	609	248	1,275
1908.					
January....	3,552	1,888	1,064	218	0
February...	5,403	2,390	560	232	95
March.....	4,243	1,801	590	248	204
April.....	1,809	910	1,450	240	0
May.....	3,310	1,302	2,580	248	2,650
June.....	4,016	1,359	2,000	240	812
July.....	6,480	2,080	1,071	248	676
August.....	7,243	1,967	1,136	248	787
September..	15,348	4,119	3,320	240	4,276
October....	12,125	3,014	2,954	248	5,610
November..	4,584	1,202	737	240	4,923
December..	4,655	1,676	609	248	154
1909.					
January.....	10,048	1,437	*	*	*

*On Toro Negro, Doña Juana and Jacaguas measurements not begun until November, 1907, and not yet calculated for January, 1909.

The Effect of the Proposed Calumet Canal on the Levels of the Great Lakes.

The completion of the Chicago drainage canal and the intercepting sewer system of Chicago has eliminated the sewage pollution of Lake Michigan along the shore southward from the northern end of the city, but the Calumet River, in the southern portion, is an increasing source of pollution by sewage and industrial waste. A canal from the Calumet River to the drainage canal, and a consequent reversal of the flow of the river, has for several years been projected by the Sanitary District of Chicago in order to remove this source of pollution.

The construction of this Calumet canal, however, has been forbidden by the United States Government (through the Secretary of War), on the ground that it would divert a quantity of water sufficient to permanently lower the levels of the Great Lakes and thereby interfere with navigation. The question of the relation of the drainage canal to the maintenance of lake levels was discussed in our issue of Jan. 31, 1907, in connection with the report of the International Waterways Commission. The conclusion arrived at by that commission was that the government should prohibit the diversion of more than 10,000 cu. ft. per sec. for the Chicago drainage canal. This is the amount provided for by the main drainage canal, while the Calumet canal would increase this by 4,000 cu. ft. per sec.

The Sanitary District refused to recognize the authority of the government in prohibiting this work, and the case is now before the U. S. Courts. Evidence has been given (directly and by deposition) by engineers and lake navigation experts, and it is hoped that the case will be ready to submit to Judge Kohlsaat in July. Much of this is similar to that already presented to the International Waterways Commission, and discussed in the report mentioned above. The engineering testimony on behalf of the government was largely in regard to the effect of diverting water from Lake Michigan at Chicago upon the levels of lakes Michigan and Huron, as well as upon the lower lakes. It is understood that the Sanitary District will make use of this same evidence in support of its own side of the case, by an endeavor to show that the results of observations differ to such an extent as to indicate that it is impossible to determine definitely or reliably what will be the actual effect of the diversion. The government, however, takes the position, that in any case the question is primarily a legal one, and that the Sanitary District has no right or authority to proceed with the work which has been prohibited by the Secretary of War. The only proper course would be to apply to Congress, which has the supreme power and could, if it chose, grant the District the authority to build the canal and divert the water.

The purpose of the government testimony is to show that the diversion of the amount of water desired for the Calumet canal would necessarily lower the mean lake level. The actual level is not constant, varying with the winds, rainfall and other influences; but its relative or mean level would be lowered by the diversion of water at Chicago. The question of establishing regulating works at the St. Mary's River (the outlet of Lake Superior) or at the Niagara River (the outlet of Lake Erie) has not been considered as a part of this case, for the reason that the results of such works are very much in dispute at this time, and the projects are only tentative.

Mr. L. C. Sabin, M. Am. Soc. C. E., General Superintendent of the St. Mary's Falls Canal (at Sault Ste. Marie) stated that it is not possible to divert a given quantity of water from Lake Michigan (other conditions remaining the same) without affecting the level of the lake. Such factors as wind and rainfall might (for a limited period) cause an actual rise of the level after the diversion was made, but this rise would be still higher if the diversion had not been made. From observations it is computed that a change of outflow in the St. Clair River (the outlet from Lake Huron) of 23,800 cu. ft. per sec. would result from each change of level of 1 ft. in lakes Huron and Michigan. He estimated that a diversion of 10,000 cu. ft. per sec. at Chicago, would result in lowering these two lakes by 5 ins. (as a minimum) to 7¼ ins., the latter being the more probable. The proposed diversion of 4,000 cu. ft. per sec. would result in a lowering of 2 to 3 ins. He further estimated that a diversion of 10 000 cu. ft. per sec. from Lake Michigan would lower Lake Erie about 5½ ins. and Lake Ontario about 4½ ins. He considered that the observations and computations allowed of stating these figures with an allowable error of not over ½-in.

Up to 1890, a change of 1 ft. in the level of Lake Huron would have lowered the level in the St. Mary's River (below the Sault Ste. Marie lock) by 0.47 ft. The mean fall from the lower end of the lock to the lake was then 2.1 ft. The improvements in the river have reduced the fall, so that at present the change in the river level would be from 0.60 to 0.75-ft. for 1-ft. change in the lake.

A change of 1 in. in the draft of the larger class of lake vessels means a change of 80 to 85 tons in cargo, and most of the steamers now being built are of the larger class. In April, 1909, there was an available draft of 18 ft. 3 ins. on the sill of the Poe lock at Sault Ste. Marie. In 1907, there were 360 boats which could be loaded to a draft of 19 ft. or more. In 1907, also, the draft on the sill was from 19.5 ft. to 20.8 ft.; these figures are monthly averages, and do not represent the maximum variation, the level varying hourly. He has seen fluctuations of 6 ins. in 24 hours in the lower St. Mary's River. Vessels deeply loaded touch bottom in the St. Clair and Detroit rivers, as they did in the St. Mary's River before it was improved.

Lieut.-Col. C. McD. Townsend, M. Am. Soc. C. E., Corps of Engineers, U. S. A., stated that the critical points for large vessels are the Poe lock (at Sault Ste. Marie), and the lower end of the Detroit River. Every inch of loss in draft means less cargo on the large vessels. The new lock at Sault Ste. Marie, which will be completed in about five years, will give a depth of 24½ ft.

Mr. E. S. Wheeler, M. Am. Soc. C. E., U. S. Assistant Engineer, stated that Lake Superior is in general about 20 ft. higher than lakes Huron and Michigan, but the difference varies. Lake Huron is in general 8½ ft. above Lake Erie, but the difference has ranged from less than 6 ft. to over 10 ft. In 1900, a board of engineers on deep waterways reported that the mean level of Lake Huron was apparently 1 ft. lower than 15 years previously. Investigations did not sustain this, the average difference in level between Lakes Huron and Erie being 8.52 ft. for the period 1860 to 1880, and 8.47 ft. for the period 1880 to 1887.

The diversion of 4,000 cu. ft. per sec. at Chicago would undoubtedly diminish the flow of the St. Clair River by an equal amount. A change in elevation of 1 ft. in Lake Huron would be equivalent to a change of 25,200 cu. ft. per sec. in the discharge; and a diversion of 10,000 cu. ft. per sec. would consequently result in lowering the level by 0.397-ft. It would take about four years to reach the full effect of the lowering. The diversion of 10,000 cu. ft. or 4,000 cu. ft. per sec. would lower the level of lakes Huron and Michigan by 4.76 ins. or 1.9 ins., respectively; the lowering being approximately ½-in. for each 1,000 cu. ft. per sec.

Gen. O. H. Ernst, U. S. A., M Am. Soc. C. E. (Chairman of the American Section of the International Waterways Commission), stated that a diversion of 10,000 cu. ft. per sec. from Lake Michigan at Chicago would lower Lake Michigan about 0.52-ft. (6¼ ins.), and lakes Erie and Ontario about 0.45-ft. and 0.35-ft., respectively. He quoted the following paragraphs (written by him) in the report on the Chicago Drainage Canal made by the International Waterways Commission:

> Variations in the level of the lake surface, due to winds and to change of barometric pressure, are frequent and irregular and at times violent. Variations of more than 6 ins. are very common, often occurring hourly for many hours in succession, while variations of 2 or 3 ft. within an hour are not uncommon. Besides these irregular variations there is a regular annual variation due to difference in rainfall, evaporation, and run-off, the water level being highest in mid-summer and lowest in mid-winter. The levels are effected also by the greater or less severity of the winter and the consequent greater or less decrease in the discharging capacity of the outlets by ice.
>
> In order to study the annual oscillations it is necessary to eliminate the irregular oscillations, and that is accomplished by using the average levels for a month. Using the monthly mean levels it is found that the regular fluctuation in Lakes Huron and Michigan usually does not exceed 2 ft. in any one year, but in a long series of years there is a great difference in the height to which high water will rise. The highest high water (monthly mean) recorded for that lake was in June, 1886, and the lowest high water in June, 1896, the difference between the two being over 3½ ft. The first is what navigators of the Great Lakes call a high-water year and the second a low-water year.
>
> It is evident that the average level of the lake may be lowered considerably without the change becoming immediately apparent, and that fact has been used as an argument to prove that the lowering caused by the Chicago Drainage Canal is of no consequence to those interested in navigation. Since they cannot see it they will not know it and will not feel it. The argument is fallacious. It is true that they cannot see it immediately, but they will soon feel it and will know it through the most costly means of acquiring knowledge—the injury to their material interests. The oscillations will remain the same as before, but low water will fall lower and high water will rise less high. The average draft of vessels must be diminished by the amount that the average level is lowered unless the depth be restored by remedial works.

The effect of the diversion of water at Chicago upon the level of lakes Michigan and Huron, as given in the evidence above noted, may be summarized as follows:

Diversion from lake: Cu. ft. per sec.	Change in lake level. Sabin.	Wheeler.	Ernst.
10,000	5 to 7½ ins.	4.76 ins.	6¼ ins.
4,000	2 to 3 ins.	1.90 ins.	.....

The primary feature of the controversy, however, is the question as to the jurisdiction and

authority of the Secretary of War in regard to work affecting navigable waters. The actual effect of the work upon the lake levels is a secondary issue. We have obtained the following statements as to the position of the government and the Sanitary District, respectively, from Major Thomas H. Rees, Corps of Engineers, U. S. A., in charge of the United States Engineer Office at Chicago, and from Mr. Isham Randolph, M. Am. Soc. C. E., Consulting Engineer for the Sanitary District.

The Position of the Government.

By MAJOR THOMAS H. REES, U. S. A.

The law (Sec. 10, Act of March 3, 1899) provides that

> it shall not be lawful to excavate or fill or in any manner to alter or modify the course, location, condition or capacity * * * of the channel of any navigable water of the United States unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same.

The Sanitary District of Chicago proposed to construct a drainage channel from the Little Calumet River, near Blue Island, to the main drainage canal at Sag, with a view to reversing the flow of water in the Calumet and Little Calumet rivers and directing it from Lake Michigan toward the main canal and the Des Plaines River, for the purpose of disposing of the sewage and wastes of South Chicago. The District applied to the Secretary of War for the necessary authority. This application was disapproved on the ground that further diversion of water from Lake Michigan would result in a lowering of the surface level of Lake Michigan and of the waters and channels to which it is tributary, thereby decreasing the depth of navigable channels and harbors of the Great Lakes to the injury of navigation.

Notwithstanding that the necessary authority had been denied, the Sanitary District began work on the Sag Channel, whereupon the United States brought an injunction suit against the Sanitary District to restrain it from continuing the work. This suit is now before the United States court.

The principal point at issue is the validity of the law which gives to the Secretary of War the power to grant or deny permission to alter or modify the course, location, condition, or capacity of the channel of any navigable water of the United States. The United States claims that the law is valid under the commerce clause of the Constitution, and that the action of the Secretary of War in such cases is final. With respect to these particular waters, there are also international considerations affecting the rights of Canada, which make it imperative that the United States shall have absolute control over the waters of the Great Lakes.

Unfortunately, there has been injected into the pending suit a discussion of the merits of the case in regard to the actual effect that the further diversion of water from Lake Michigan will have upon navigation, and thereby the main issue is in some danger of being obscured. The questions that arise in this discussion are as follows:

(1) To what extent will the surface levels of the lakes be lowered by the diversion of 4,000 cu. ft. of water per sec. from Lake Michigan through the proposed Calumet-Sag channel?

(2) In what time will the lowering of the surface levels of the lakes be effected?

(3) What are the present limiting depths of water in lake harbors and connecting channels?

(4) What will be the effect of diminishing the draft to which lake vessels may be loaded?

(5) What would be the cost of regaining, by means of dredging and rock excavation, the depths that would be lost by reason of the diversion of water through the proposed channel?

(6) Can the surface levels of the lakes be controlled by regulating works at their outlets, and what would be the cost of such regulation?

(7) Considering their international character, what are the uses or purposes to which the waters of the Great Lakes may legitimately be applied?

(8) Assuming that each State or Dominion bordering on the Great Lakes owns or controls a share in their surplus waters that is proportional to its included area of lake drainage basin, what is the share of the State of Illinois?

The Position of the Sanitary District of Chicago.

By ISHAM RANDOLPH, M. Am. Soc. C. E.

This case arose out of the adoption by the Sanitary District of Chicago of a plan to reverse the flow of the Calumet River and carry it through an artificial channel, extending from Blue Island through the Sag Valley to a junction with the main channel of the sanitary and ship canal, about 18 miles southwest from Robey St., Chicago. (At Robey St. the sanitary canal leaves the west fork of the Chicago River.)

This plan contemplates the withdrawal of 4,000 cu. ft. of water per sec. from Lake Michigan through the Calumet River, which would prevent the discharge into Lake Michigan of the sewage which now enters the Calumet River from that section of Illinois which it drains and also from Indiana. This is a natural outlet for the low country lying in the northwest part of the State of Indiana.

The Secretary of War refused to issue a permit under which this work could be carried on, and an injunction was threatened if any attempt was made to prosecute the work. The Sanitary District committed a technical overt act in commencing the work, but desisted upon condition that the government would not sue out an injunction, but would bring suit to test the respective rights of the government and the State of Illinois in the premises. The contention of the government is that the withdrawal of this water will lower the lakes Michigan, Huron, Erie and Ontario to an extent which would be damaging to navigation. The extent of this lowering is claimed by the government engineers to be 2½ ins. in lakes Michigan and Huron, with a diminishing effect in lakes Erie and Ontario.

In testimony so far taken an effort has been made on the part of the government to prove the correctness of the contention that the lakes would be lowered as stated. The effort of the Sanitary District will be to demonstrate (1) that there is a failure on the part of the government to make proof, and, further, that the use of this water for the purpose of the preservation of life and health of the inhabitants of a great city is a use paramount to the use of the water for navigation; (2) that the slight (and, as we believe, unproved) loss to commerce due to a lowering of 2½ ins. is a matter of minor importance as compared with the preservation of human life; (3) furthermore, that as an offset to the slight injury to the lakes, the diverted water will facilitate and develop commerce of vast importance to the deep waterway from Chicago to St. Louis, and by the Mississippi River to the Gulf.

We are depending for the facts to sustain our contentions, so far as the Great Lakes are concerned, upon data gathered by the engineers of the United States government. They are custodians of these data and vouch for their accuracy and reliability, and it is for the District to use government ammunition to destroy the government case.

THE PRODUCTION OF PIG IRON for the year 1908 has been compiled by the U. S. Geological Survey for "Mineral Resources of the United States, 1908." The output is given as 15,936,018 long tons—a decrease of 38.19% from the output in 1907. The value of this pig iron, on board cars at the furnace, is given as $254,321,000, which is 52.01% less than the value of the 1907 output. The product derived from imported foreign ores has been considered such a small percentage of the total that it could be neglected in this compilation.

THE CONCRETE TRESTLES with solid slab floors, which were described in our issue of May 20, show no tendency to creeping. This might be expected owing to the great weight and thickness of the slabs which form the spans, and the friction between the concrete slabs and cops. Furthermore, there is no tendency of the traffic to cause creeping (as in the case of wooden trestles), as the track is insulated from the floor by a bed of stone ballast. The abutments have end walls which would receive end thrust, if any. In some cases a mortar joint has been used between the slab and cap, but this is not considered necessary. The slabs are coated with a tar composition for waterproofing, and where this touches the contact surfaces it makes a very tight joint.

Rock Tunnel Advance and Rock Tunneling Machines.

The great difference between American and European records in speed of advance in rock tunnels has often been remarked upon. An editorial memorandum of the principal records made in America and on the continent of Europe was given in our issue of April 2, 1908, p. 377. Any such list shows conclusively and at first glance that the phenomenal figures attained in the Alpine tunnels are not due to the specific excellence of European types of rock drill.

It is true that the high record of 6.35 ft. in a single heading during one month, made in the Simplon tunnel, was popularly credited to the hydraulic rotary drills used in that work. And by inference it was concluded that the backwardness of American records is chargeable to the exclusive use of pneumatic percussion drills. But these conclusions are absolutely destroyed by a series of comparisons of which we need cite only two: (1) In other tunnels, percussion drills had shown themselves capable of holding their own with the Brandt rotary; and (2) in one tunnel, where hand drills only were employed, the best

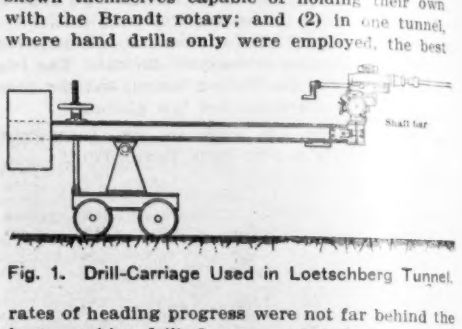


Fig. 1. Drill-Carriage Used in Loetschberg Tunnel.

rates of heading progress were not far behind the best machine-drill figures, and indeed were far ahead of any American records whether hand or machine. The latter observation proves, of course, that the important factor is something other than the type of drilling-machine used. The comparison of percussion drill with rotary is further illuminated by a most remarkable figure recently reported from the Loetschberg Tunnel, where percussion drills made an advance far ahead of the Simplon record.

Mr. W. L. Saunders, who has long been identified with rock-drill manufacture, makes an interesting contribution to the discussion by a paper entitled "Driving Headings in Rock Tunnels," published in the April (1909) Bulletin of the American Institute of Mining Engineers. He there treats of the advantage which the drill-carriage method of working possesses, as compared with the tripod or column method of mounting drills, and makes it clear that the drill-carriage deserves a new trial in American practice.

The paper further discusses the subject of tunneling machines, of which one, the Terry, Tench & Proctor machine, was recently described in these columns.* A number of machines for this class of work have been invented recently, and some have been built for trial in actual work. Mr. Saunders describes only a few of them, but he makes it evident that he has no great faith in their future.

Extracts from the paper are as follows:

> There is no department of rock-excavation so difficult as that of heading-driving. This work also belongs to the most expensive class in rock-excavation. A heading is driven directly in the solid. There are no lines of lesser resistance towards which to direct the energy of the blast, but the material must be blown out by main force. The completion of the heading simplifies all the rest of the work of excavation. It is easy, for instance, to enlarge a heading either from above, below or on the sides, by breaking towards the open face through holes approximately at right angles to the axis of the heading; or the enlargement sometimes takes place by holes driven outside of the heading running approximately parallel with it, the rock being broken into the heading. All of this is bench-work, or stoping; it involves little difficulty, and a minimum of explosive is required, because there is an open end or face towards which the energy of the blast is directed.
>
> Driving seems to be the fitting term to use for tunnel construction, because, from beginning to end, every other consideration is sacrificed to progress. The tunnel is

*Eng. News, Nov. 19, 1908, p. 556.

worthless until completed, and the capital involved in its construction is locked up and unprofitable.

Progress in heading-driving is dependent, first, upon an efficient boring-apparatus and system, and, following closely upon this and of perhaps equal importance, upon the system of blasting. The nature of the rock has a great deal to do with heading-progress. A hard rock which shatters easily is usually more favorable than a tough, soft material. The direction of the dip or of the cleavage of the rock has a good deal to do with progress. Fissures, pressure in the rock, water-bearing strata, heat, gas, and soft spots, resulting in falls, are hindrances to progress.

Driving a heading in solid rock is, of course, primarily a job for the rock-drill. Where the best records are made, the natural inquiry is as to drill employed, yet the importance of this is frequently overestimated. The system is of equal importance. The best rock-drill, or the one which drills fastest, might be handicapped if insufficiently mounted, since the holes driven in headings are invariably of moderate depths, so that much of the time is employed in changing the drill from one hole to another, changing steels, etc.

Too little importance is given to the question of how a rock-drill is mounted. An illustration of this is shown by comparing the drilling capacity of a machine when used, for instance, on a tripod or a column with that of the same type and size of rock-drill mounted on a gadder-frame or quarry-bar. The usual work of a rock-drill in average material is from 50 to 100 lin. ft. of hole in a day of 10 hours. This machine, when mounted on a gadder-frame or quarry-bar, will do 350 lin. ft. of hole in the same time, the difference being made up, not in the drilling-capacity, but in the facilities afforded for rapidly changing from one hole to another.

The remarkable records in tunnel-driving made by the hydraulic drills used at the Simplon tunnel have always been attributed to the efficiency of the boring-machine. These Simplon headings were driven at the rate of about 20 lin. ft. in 24 hrs., and in hard rock, while American tunnel-driving seldom exceeds 10 ft. in 24 hrs. when driving in hard rock, so that here we have a difference of 2 to 1 against the American system. But the remarkable records made at the Simplon have practically been equaled by the work now going on in the Loetschberg Tunnel, this latter being equipped with percussion drills mounted on carriages similar to those used at the Simplon.

The paper then gives lists of American and European records in speed of heading advance (substantially as presented in our issue of April 2, 1908,) and points to the superiority of the European performances. It then takes up for special mention the method of working which is now being used in the Loetschberg Tunnel.

This 8.5-mile tunnel, between Goppenstein and Kandersteg, destined to give a shorter northern approach to the Simplon tunnel, is driven by Ingersoll rock drills in the South heading, and Meyer drills, also of the pneumatic percussion type, in the North heading. Though in this it differs widely from the Simplon Tunnel, it is similar to the latter in its drill-carriages. The Loetschberg drill-carriage and the order of excavation was described rather fully by Mr. W. I. Aims in our issue of Dec. 31, 1908, and a sketch of the car was there shown. That article may be referred to in connection with Mr. Saunders' remarks; a sketch of the carriage is repeated here as Fig. 1.

There is a single track, about 30-in. gage, in the bottom heading, this heading being widened out where the upraises are to come, and the track being turned out at these points. On this track travels a special car, which carries a normally horizontal, tilting counterbalanced steel beam, upon the forward end of which is secured a horizontal bar, and upon this bar are four drills. The swinging of the beam upward or downward, and the placing of the drills above or below the bar, gives them all the positions for the 12 or 14 holes usually required for each round.

The original car and mounting designed for this service may be described as too much of a good thing, and it was never used. On this car were two of the balanced, vertically-swinging beams, each carrying its shaft or tunnel-bar, and on each of these three or four drills would have been mounted. The ends of these two bars were telescoped, and it was designed to clamp and hold the bars in working position by forcing the ends out against the sides of the heading by hydraulic pressure. An important and conspicuous feature of the car was, therefore, an air-operated duplex water-pump to furnish and maintain the required pressure.

The car actually used was a much simpler affair (Fig. 1). This car was built by the Ingersoll-Rand Co. It carries only a single balanced, vertically-swinging beam with a single bar pivoted to swing horizontally above the forward end of it, and the bar is secured against the sides of the heading by the usual jack-screws, so that the water-pump is dispensed with. The bar is pivoted above the beam so that when the car is run backward or forward the bar may be swung around, above and parallel with the beam, leaving no interfering projections to catch the sides of the heading. Four 3⅝-in. Ingersoll-Rand drills are mounted on the bar, each, of course, with a separate air-connection, but all connecting by a manifold with a single hose at the rear of the car.

Either 12 or 14 holes are drilled in each round. These are 4 ft. deep and 2 ins. at the bottom, in four vertical rows, the inner rows running nearly parallel with the tunnel axis the same as the rest. As soon as the holes are all drilled the bar is swung around straight and the car is run back to the last turnout until the blasting is done. Before the blasting, a ⅝-in. steel plate, 6½ ft. by 3¼ ft., is laid down just ahead of the end of the track, and after the blasting is over a cut is quickly made through the center of the muck-pile down to the plate, and the tunnel-carriage is run forward on this, the bar is set again, and the drills begin the top row of holes. Mucking-out continues during the drilling.

The use of this carriage facilitates the mucking to a considerable degree. After the blast in the usual American tunnel there is a mass of muck reaching nearly to the roof piled up in front and close to the face of the heading. This muck is shoveled away only to a sufficient degree to allow the men to climb over it and dig holes close to the face for the purpose of placing the columns which carry the rock-drills. The use of this carriage, with the bar which carries the drills projecting forward some 12 ft. or more from the truck, requires that the first mucking be done on the steel plate on the floor, and only sufficient to make a trench through the center of the heading, so that the tunnel-carriage may reach close enough to enable the drills to begin operations in the top holes over the muck. Here we have the drills at work earlier than with the American system, and the muckers have a better opportunity to load the cars, because the material is scattered on each side of the heading instead of being piled up only at the face.

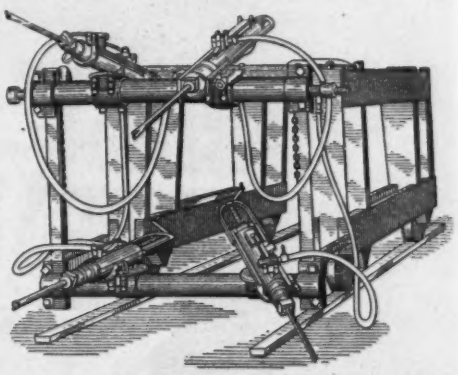


Fig. 2. Drill-Carriage for Old Burleigh Drills, Hoosac Tunnel.

Where the rock-drills are mounted on a bar carried by a tunnel-carriage it is easier to keep them in condition, free from muck and grit, than with the American system, where they are detached from the column-arms and laid on the floor. This is an important point, not only in reducing maintenance expense and decreasing wear in the cylinder and other moving parts, but also in lessening the difficulty in keeping the stuffing-boxes tight, resulting in a smaller leakage of air.

Blasting is done by fuse-and-cap method, the fuses being all fired at the same time, but the length of the fuses is such that the center holes are fired first. By this system time is saved, but there is some danger of missed holes, and to minimize this three fuses are used in the bottom holes and two in all the others. The explosive used is 60% dynamite, made at Brieg. The center holes are charged with 6 lbs. each, and the average total charge for the 12 or 14 holes is from 53 to 57 lbs. The holes are not very deep, not exceeding 4 ft., starting 2.5 ins. and finishing 2 ins., to take cartridges nearly 2 ins. in diameter.

Experience has shown that the drill-carriage is indispensable if the rapid advance is to be maintained, though it is not without its objectionable features. The fact that all the four drills on the bar are in the same horizontal plane makes it difficult to give the upwardly-inclined holes just the same angle they could have if the drills were on separate columns, and to get a clean break to the bottom of the hole more explosive must be used.

ADVANTAGE OF QUICK ADJUSTMENT.—This disadvantage in a horizontal bar over the vertical columns is more than compensated for by the readiness with which the bar may be set in place and jacked. One bar only has to be jacked, and that across the tunnel horizontally against the walls, which are usually rigid, while with the column system there are two, sometimes three, columns to be placed in position, each in a separate place, and each one must have a firm base, which is not always available close to the face of a heading just after the blast.

But this is not all, nor is this the most important function of the tunnel-carriage system. By its use, and because of the facility which it affords for readily mounting the rock-drill and moving it from one hole to another, it is possible to put in a large number of shallow holes of large diameter as against the American system, which is a small number of deep holes of small diameter. It must be understood that when a rock-drill mounted upon a column has once begun its work in a heading, so much time has been occupied in placing it in position, getting the jack-screws tight, and pointing the hole itself, that we have fallen into the habit of keeping it there and putting in as deep a hole as we reasonably can consistent with the dimensions of the heading, the nature of the rock, and the angle of the hole.

ADVANTAGE OF SHALLOW HOLES.—Other things being equal, a deep hole can be drilled faster than two or more shallow holes, the combined depths of which are equal to the deep hole. The difference is made up in the time lost in changing the mounting, whether that mounting be a column or a tripod. The deeper the holes are driven the smaller is the diameter of the hole at the bottom, and we know, of course, that it is at the bottom of the holes that we want the greater amount of concentrated explosive force, and that the larger the hole is at the bottom the better is the effect of the blast. A theoretically-perfect hole would be one larger at the bottom than at the orifice, but this is not practical in tunnel-work, hence we must suffer the loss of gage, and by an excessive amount of explosive, by good tamping, and other means, try to make up for this handicap.

LARGE NUMBER OF HOLES.—Another habit which we have fallen into is, that too small a number of holes is drilled in the heading. This is because we have found it difficult to make reasonable progress in hard rock by drilling an adequate number of holes, owing mainly to the fact that the mounting must be changed from one place to another. Having the habit of deep holes, we find it necessary to start them in a certain particular place, so that they will bottom just where we want them in order to break the ground. Now, it is just in this that we see the disadvantage under which the column system suffers.

Having the horizontal bar used in the Loetschberg tunnel with four percussion drills mounted upon it, and this bar being practically balanced on a little tunnel-carriage and easily jacked in place across the walls, we begin putting in a hole with each machine. If one bottoms its hole ahead of the others it is simply swung on its radius, the center of the axis being the bar itself, and another hole put in. All of these holes are shallow, and being shallow they are naturally of large diameter. One meter is the usual depth, or a maximum of 4 ft. This is from one-half to one-third the usual depth of hole in a tunnel-heading under the American column system; and because the holes are shallow it is not necessary to start them in so exact a position, but as long as we have enough of them, and use plenty of dynamite, the rock is thrown out in pieces of smaller size, and usually farther away from the face of the heading, than where the blast is from a deep hole, even though it may be directed to meet another hole, the two holes practically joining at the bottom, forming a wedge, and acting to concentrate the force by means of which the center cut is made.

DRILL-CARRIAGE USED IN HOOSAC TUNNEL.—What we have always understood as a tunnel-carriage is a cumbersome affair, quite different from that used in the Loetschberg tunnel. A carriage was the first form of mounting adopted when rock-drills were used to drive the Hoosac and other American tunnels. The carriage usually occupied the entire area of the heading, and was a hindrance to progress rather than otherwise.

The sketch, Fig. 2, herewith, shows the Burleigh drill-carriage used in the Hoosac and other early tunnels. This is the original form of tunnel-carriage, and attention is drawn to a comparison between Figs. 1 and 2. The Burleigh carriage occupied too much space and was too cumbersome for practical tunnel-driving. It did not afford facilities for mucking, and too much delay occurred after a blast before the carriage could be run close enough to the heading for the drills to begin work. The Loetschberg machine, with its small truck and short wheel-base, need not approach very close to the heading because of its overhanging arm. The two to four drills, mounted on the single shaft carried by the arm, are quite sufficient for all ordinary heading-purposes.

FIRING BY FUSE.—Next in importance to the system of mounting the drills is the system of blasting. Because of the larger number of holes, the greater diameter, and because the holes are not directed on lines of maximum breaking-efficiency, a great deal more explosive is used than in the American system, but dynamite is cheap—much cheaper in fact than time and labor. To blast by fuse instead of by electric battery would seem to be a step backward, and yet in this class of work it has some advantages. With the electric system the heading is wired and the center or cut holes blasted

first. After this the wires leading to the side rounds are connected, and it frequently happens that the first blast has damaged the wires or has covered them so that considerable time is lost in getting ready for the side-round blast. Broken wires result in mis-fires. The use of the time-fuses means that the whole heading is fired practically in one operation, though there is a lapse of a few seconds between the discharges, owing to a difference in lengths of the fuses, the shorter fuses being connected with the center-cut holes, and the length of fuse being increased in proportion as the side-rounds are blasted from the center. Mis-fires also occur with the fuse system, but this is minimized by employing two or three fuses and caps in each hole.

It takes less time to connect these holes by fuse and to fire them than it does to connect wires, to see that they are properly insulated, to couple up the leading wires, and to discharge the battery, especially so when through the system of deep-cut holes it is found necessary in American tunnels to blast the center first and the side-rounds alternately afterwards.

Tunneling Machines.

In discussing tunneling machines, whose basal idea is to keep the drills at work all the time by eliminating blasting, Mr. Saunders points out that they propose cutting up into chips the entire volume of excavated material, while in the drilling-and-blasting system the drills cut considerably less than 1% of the material. But the time available for drilling will be multiplied only by three or four, while the work to be done is multiplied more than a hundred times; thus it is difficult to see how better progress can be made by such machines.

He remarks that there is no commercially successful tunneling machine at the present time, and says:

> Were nitroglycerine and dynamite undiscovered, the tunneling machine would be of great importance.

As an introduction, he describes the "Radialax" method of driving headings, which represents a departure from the typical drilling-and-blasting system in the direction of increased proportion of drill work. The "Radialax" machine is a small pivoted channeler, which is used to make a vertical center cut in the heading face. This acts as a free face for the blasting holes on either side, and the rock breaks toward the channel.

Five tunneling machines are then described. These are by no means all, and reference is made to a compilation by H. A. Everest* of a list of some 30 different machines, ranging in date from 1853 to the present.

PROCTOR MACHINE.—This machine† is the joint production of O. S. Proctor, of Denver, and E. F. Terry, of Terry & Tench Co., contractors, New York. This is to cut a tunnel or heading 8 ft. in diameter, converting all the material into dust or chips. There is a four-wheel truck at the rear which travels on a track, and the front end is carried by two conical wheels, which fit the circle of the tunnel on each side and thus keep the head central. The main shaft, which is hollow, has adjusting-screws at the back by which the direction of advance may be controlled either vertically or horizontally. In the middle of the track is a rack by which the machine is fed along and constantly held up to the work. This feed is by means of an air-engine and worm-gearing on the truck. Another air-engine with another train of gearing slowly rotates the head. This head has a hub, a casing, four connecting-arms, and four bars which carry pneumatic hammers with chisel bits. Upon three of the bars six hammers are mounted, and upon the fourth bar there are seven, and as the head rotates they cut along different overlapping circles and thus cover the entire face of the excavation. Steel plates fixed between the groups of hammers are arranged to form pockets to catch and carry away the rock chips. These discharge into a hopper at the rear of the rotating head, and a conveyor leads to the rear of the machine. The designers estimate that this machine will be capable of removing 5,000 cu. ft. of rock per day, which would be equivalent to an advance of 100 ft., and, of course, three or four times as fast as by the drilling-and-blasting method. It is also calculated that $300 per day will be sufficient to meet all the expenses involved in operating the machine.

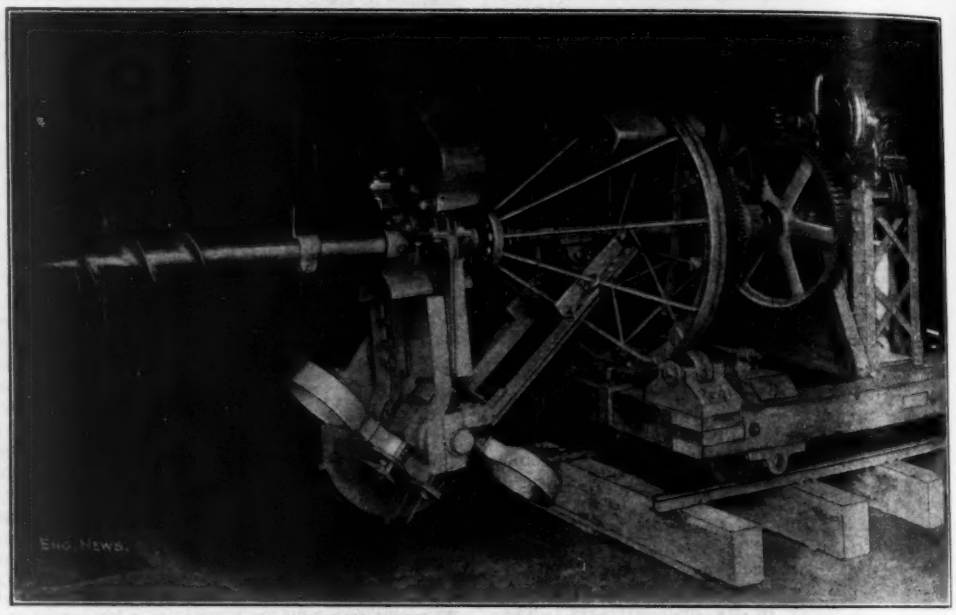
KARNS MACHINE.—This machine, the invention of J. P. Karns, formerly of Cripple Creek, may be called an enormous percussion-drill reciprocating a single cutter-head. The first machine tried in the Cripple Creek district used a column to support it. The company has at Magnolia, Colo., a 6-ft. machine mounted on a carriage. The head is 4 ft. in diameter, and is attached to a 9-in. shaft, which extends about 10 ft. to the back of the carriage, where it has a spherical direct connection with the 4-in piston-rod of the actuating cylinder. The head rests on a cylindrical shield, which in turn bears on small wheels. The shield carries 3-in. balls on which the head rolls, and these balls rest on eighty ⅝-in. balls. There is much more of complicated description which we cannot profitably follow. The cutters are made of bars 1 in. thick, 4 ins. high, and of lengths varying from 9 to 24 ins. Their faces are serrated so that there are a number of square pyramids on each. The cutters are arranged in three sets, the outer set having 24 cutters of medium length, the next set having 17, one being left out so that a man can get through the head, and the center set having 4 short cutters in advance of the others, which help to keep the machine in its path. An endless scraper, 27 ft. long, driven by a small three-cylinder engine, is provided to remove the cuttings, but it is expected that they can be flushed out by water.

This machine has actually done some work. A short run was made a year ago. The engine used was too large to follow in the bore of the 6-ft. cutter, and the compressors were too small to maintain more than one-half the pressure desired. The machine was run 6 mins. 30 sec. for an advance of 2 ins. The rock was a fairly hard syenite, composed almost entirely of feldspar.

SIGAFOOS MACHINE.—This machine, invented by R. B. Sigafoos, of Helena, Mont., is an electrically-driven machine, and the entire machine rotates upon wheels, which may be given a helical pitch to advance or withdraw the machine by its own rotation and to feed it slowly against the rock when in operation. The work is done by crushing or pulverizing the rock and washing it out with water under pressure. The rotating frame carries 10 crushing-heads, each mounted on a 4-in. shaft. These are withdrawn by cam action, and a long, heavy helical spring shoots the shaft and crushing-head forward, the several heads striking in succession. The frame is made up of two heads connected by a 6-in. central rod and eight 1½-in. tie-rods near the outside. The length over all is about 18 ft., and the weight is 20 tons; the weight is considered sufficient to hold it up to its work. Eight of the cutters are on the outer edge of the machine and two are near the center. The heads are about 2 ft. in diameter and about 5 ins. thick. The teeth are not sharp and do not require sharpening. The cuttings are to be flushed out by a 3-in. stream of water under 40 lbs. pressure, fed through the central shaft, and a spray-head keeps a ⅝-in. stream behind each cutter. A 150-HP. electric motor will be used, it being assumed that 65 HP. will be required to start the machine, while half of that will be enough to keep it going.

FOWLER MACHINE.—The machine of George A. Fowler is one of the latest which has come to the knowledge of the public, and its scheme of operation is different from that of any of the others. It is expected to cut a rectangular face 7 × 6½ ft., using 38 percussion-drills, all operating at once and all being moved about to cover the entire area while in rapid operation. The drills are arranged as a battery upon a massive cast-steel head hung by heavy hinges from the front of the machine. This head is to move back and forth to cover the entire face three times a minute, the drills striking at speeds up to 1,000 per min. The movement of the head is not absolutely automatic, but can be controlled by the operator according to the requirements of the rock. There is no rotation of the bits, and the drills are not quite parallel, flaring enough to provide for necessary clearance and to the full area as the work progresses. The cutting-battery is framed in a shield which of the tunnel all around, inclosing all collect at the bottom, where they can ward on to an elevating conveyor by haust of all the drills and delivered to The valve-motions of the drills and oth machine are novel and interesting, consider them here.

BENNETT MACHINE.—This machine, G. R. Bennett, of Denver, is rather take seriously than even some of the ot 48 hammer-drills with 4-in. bits, drill to a depth of 2 ft., then withdrawing a erally and again vertically until eight of holes have been drilled, thus covering area of 8 × 5½ ft. with 384 holes, all resettings being done automatically. The eight in a row horizontally, 8 ins. on centers, and they are spaced vertically 4 ins. on centers in two sets of three each with 12 ins. between the sets. The drive is electric, each vertical set or battery of six having one feed-cylinder and one driving-pinion, the sets striking alternately. The sets of drills are fed forward 2 ft.; as each set finishes its cut it is drawn back and the power is automatically shut off, and when all eight of the sets have thus finished their cuts the machine shifts over 4 ins., and another cut is made. When this cut is done the drills are all dropped together 1 ft. and the previous drilling-operations are repeated. This finishes the upper half of the face; the drill-carriers now drop 3 ft., and a repetition of all the previous operations completes the entire face. It is thought that the webs of rock remaining between the holes will break down of themselves, but if they should remain until the series of holes are all drilled a man can go in and quickly break them down. It is not assumed that any of this breaking away could interfere with the constantly automatic action of the drills and shifting-devices.



TUNNELING MACHINE FOR SOFT GROUND, DESIGNED BY W. F. BROWN, TOLEDO, O.

A Machine for Tunneling in Earth.

The photograph above shows a machine for driving headings in clay or other soft soils, designed by Mr. W. F. Brown, of Toledo, O. It comprises a revolving double-spoon excavator which works in the radial plane, cutting from center to circumference; an auger pilot which alines the machine, and a frame which rotates the assemblage of auger and excavator about the longitudinal center-line. The designer is reticent as to details or performance, but gives the following description:

> The machine is designed for clay cutting and is adjustable to any soil. Its capacity is 10 ft. advance per hour in an 8-ft. drift, and it may be mounted on an ordinary truck car or be attached to the interior of a shield. When mounted on a truck the machine is easily adjusted to line and grade, also to bores from 6 ft. up to any diameter. This also holds good when the machine is fixed in a shield, except that the alinement is kept by the shield. It is adaptable to cylindrical, egg-shaped or rectangular drifts and the only change necessary is in the manner of mounting the machine. The entire weight of the machine, including a 7½-HP. compound-wound motor, is only 2½ tons.
>
> The machine works automatically, cutting the clay

*Mining and Metallurgical Journal, Sept. 5, 1908.
†See for fuller description Eng. News, Nov. 19, 1908.

from the breast by a combined transverse and longitudinal revolution of the knives. The transverse motion is controlled according to the section to be taken out. The excavated material, which falls to the bottom or invert is picked up by an ingenious mechanical arrangement and carried by belt conveyor to the rear, where it is deposited in a receptacle for removal. Patents are now pending.

Mr. Brown has named his machine "The Ground Hog." The chief claims which he advances are simplicity, positive and automatic action, and strength.

A Collection of Formulas for Water-Pressure and Moments in Submerged Beams.

By D. N. SHOWALTER.*

It is the purpose of this article to collect in convenient form some of the formulas used by a designer of hydraulic work.

The formula for water-pressure against a vertical surface (Fig. 1) is

$$P = \frac{w\,h^2}{2} = 31.5\,h^2 \qquad (1)$$

where

P = total pressure in lbs. per lin. ft. of wall.

w = wt. of a cubic ft. of water.

h = depth of the water, in ft.

Taking $w = 63$ lbs. for the sake of an even figure introduces a slight extra safety factor.

The overturning moment about a horizontal axis at the base of the vertical surface is found from (1) by multiplying the pressure by its lever-arm $\frac{1}{3}h$, or

$$M = \frac{w\,h^3}{6} = 10.5\,h^3 \qquad (2)$$

where M = overturning moment about base, in foot-pounds per lineal foot of wall.

The height "C" of the center of pressure on a submerged vertical plane AB is found from Fig. 2 to be as follows:

$$C = \frac{1}{3}\,h\,\frac{h + 3\,h_1}{h + 2\,h_1} \qquad (3)$$

where h_1 is the depth of the top of the plane below the surface of the water, and h is the height of the plane.

This is merely the expression for the height of the center of gravity of the trapezoid of pressure, $ABCD$, with top width $AD = w\,h_1$, bottom width $BC = w\,(h + h_1)$, and height $AB = h$.

It is frequently required to know the thickness of plank necessary to support horizontally a given water load, Fig. 3.

Let h = depth of water in feet to the point considered.

t = thickness of plank necessary at this point, in inches.

s = span of plank horizontally, in feet.

F = safe extreme fiber stress in the plank.

Considering the plank as a simple beam 12 ins. wide and s ft. long,

Its section modulus is $\frac{12\,t^2}{6}$ in.^{3}.

The pressure per lineal foot is $63\,h$ lbs.

The maximum moment is $\frac{63\,h\,s^2}{8}$ ft.-lbs.

$$\text{Then } \frac{\text{moment}}{\text{sect. mod.}} = F = \frac{12 \times \frac{63\,h\,s^2}{8}}{\frac{12\,t^2}{6}} \text{ in.-lbs.}/\text{ins.}^3$$

$$= \frac{189}{4}\,\frac{h\,s^2}{t^2} \text{ lbs. per sq. in.}$$

whence

$$t = s\sqrt{\frac{47.25\,h}{F}} \qquad (4)$$

*Designing Engineer for Wm. G. Fargo, Civil and Hydraulic Engineer, Jackson, Mich.

For hardwood, $F = 1200$ lbs. per sq. in. then

$$t = s\sqrt{\frac{h}{25.4}} = \frac{s}{5.03}\sqrt{h} \qquad (5)$$

For soft wood $F = 800$ lbs. per sq. in. and

$$t = s\sqrt{\frac{h}{16.93}} = \frac{s}{4.11}\sqrt{h} \qquad (6)$$

It is sometimes necessary to find the strength of a semi-cylindrical trough or tank, or to find the strength of horizontal ties across its top.

In Fig. 4, let

w = weight in pounds of a cubic foot of water.

r = radius of the trough, in feet.

$r - e = D$ = depth of water in trough, in feet.

An elementary area of the shell, for a length of 1, is $r\,d\,\phi$.

The pressure at the depth of this element is $w\,(r\cos\phi - e)$. The lever arm for the moment of the pressure on this element, about point E, is $r\sin\phi$. Then the total moment of the water-pressure from E *to* F, about the point E, is

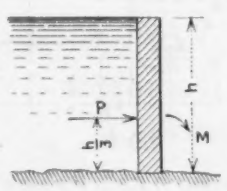


Fig. 1.

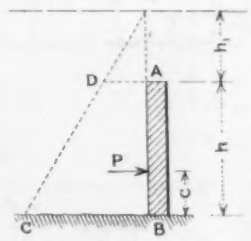


Fig. 2.

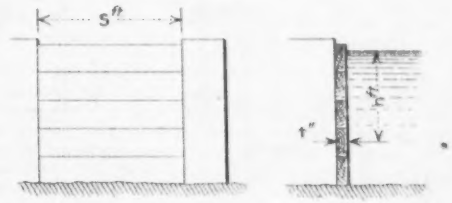


Fig. 3.

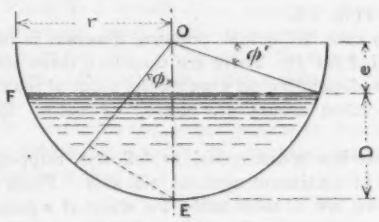


Fig. 4.

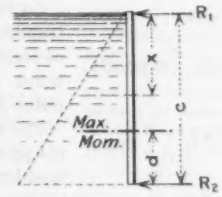


Fig. 5.

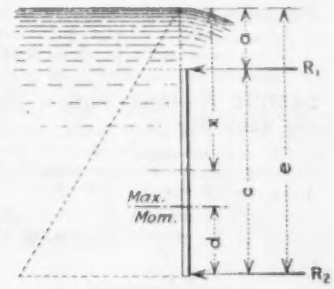


Fig. 6.

$$\int_0^{90-\phi'} r\sin\phi\; w\,(r\cos\phi - e)\,r\,d\phi$$

$$= w r^3 \int_0^{90-\phi'} \sin\phi\cos\phi\,d\phi - w\,e\,r^2 \int_0^{90-\phi'} \sin\phi\,d\phi$$

Integrating and reducing, there results:

$$\left.\begin{matrix}\text{Moment per}\\ \text{foot of length}\\ \text{at } E\end{matrix}\right\} = \frac{w\,r}{2}\left(r - e\right)^2 = \frac{1}{2}\,w\,r\,D^2 \qquad (7)$$

The stress in a tie at the top, per foot of length of trough, equals moment ÷ radius, or

$$\frac{1}{2}\,\frac{w\,r\,D^2}{r} = \frac{1}{2}\,w\,D^2 \qquad (8)$$

When the trough is full these expressions become,

$$\text{Moment} = \frac{1}{2}\,w\,r^3$$

$$\text{Tie stress} = \frac{1}{2}\,w\,r^2$$

In figuring water pressure on gates and similar structures, time and labor are saved by having convenient formulas for the reactions, the position of maximum moment and the amount of the maximum moment per lineal foot of rectangular surface subjected to various water pressures.

Formulas marked with a dagger are taken from an article by J. W. Rickey, C. E., published in Engineering News of March 1, 1898. They are given here for the sake of completeness.

CASE I. A.—Vertical surface; one support at the surface of the water (Fig. 5).

The height of the surface being called c, the reactions per lineal foot of wall are:

$$\text{Top} \quad R_1 = \frac{w\,c^2}{6} \qquad (9)$$

$$\text{Bottom } R_2 = \frac{w\,c^2}{3} \qquad (10)$$

The bending moment at a section distant x from the top support is

$$M = \frac{w\,c^2\,x}{6} - \frac{w\,x^3}{6}$$

Differentiating and equating to zero to obtain the position of maximum moment, we find

$$x = \frac{c}{\sqrt{3}} = 0.577\,c$$

$$d = c - x = 0.423\,c \qquad (11)$$

$$\text{Max. mom.} = \frac{w\,c^3}{9\sqrt{3}} = .0641\,w\,c^3 \qquad (12)$$

CASE I. B.—Vertical surface; both supports below surface of water (Fig. 6).

$$\left.\begin{matrix} R_1 = \frac{w\,c}{6}\,(c + 2\,a)\\ \text{and}\\ R_2 = \frac{w\,c}{6}\,(2\,c + a)\end{matrix}\right\} \qquad (13)$$

The moment at a point x below the surface of water is

$$M = \frac{w}{6}\left[(c^2 + c\,a + a^2)\,x - x^3 - c\,a\,(c + a)\right]$$

For a maximum, $\frac{d\,M}{d\,x} = 0$, whence

$$x = \sqrt{\frac{c^2 + c\,a + a^2}{3}}, \qquad (14)$$

and

$$d = c - x = c - \sqrt{\frac{c^2 + c\,a + a^2}{3}} \qquad (15)$$

Inserting the above value for x in the equation of bending moment,

$$\text{Max. moment} = \frac{w}{6}\left[2\left(\frac{c^2 + c\,a + a^2}{3}\right)^{\frac{3}{2}} - c\,a\,(c + a)\right] \qquad (16)$$

CASE II. A.—Slant surface; one support at surface of water (Fig. 7).

$$R_1 = \frac{w\,b\,e}{6} = \frac{w\,e^2 \sec a}{6}$$
$$R^2 = \frac{w\,b\,e}{3} = \frac{w\,e^2 \sec a}{3} \qquad \dagger\ (17)$$

The moment at a point x below the surface is

$$M = \frac{w\,e^2\,x \sec^2 a}{6} - \frac{w\,x^3 \sec^2 a}{6}$$

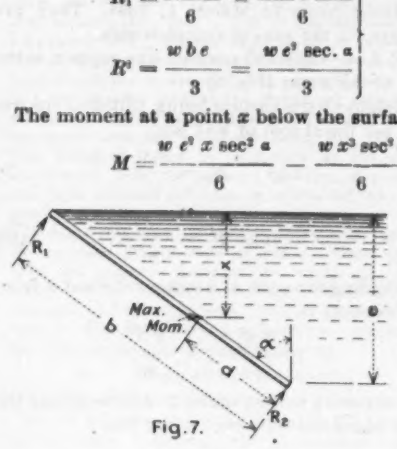


Fig. 7.

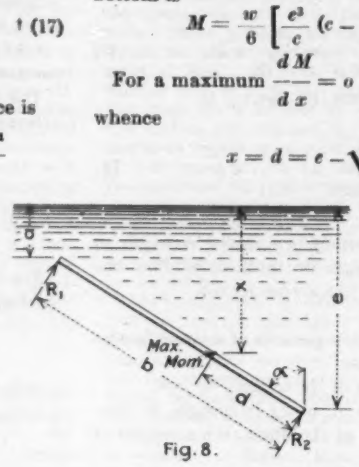


Fig. 8.

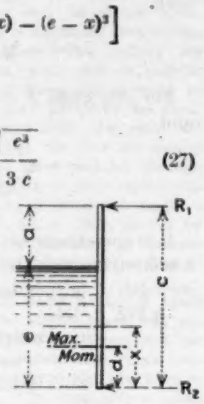


Fig. 9.

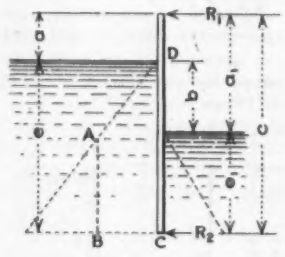


Fig. 10.

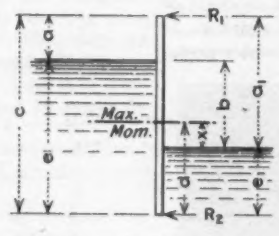


Fig. 11.

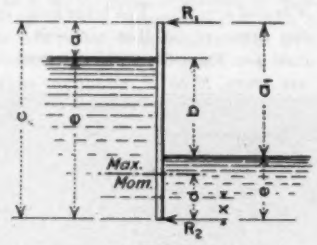


Fig. 12.

For a maximum,

$$\frac{d\,M}{d\,x} = 0 \text{ whence } x = \frac{e}{\sqrt{3}} = 0.577\,e \qquad (18)$$

and $$d = .423\,b \qquad \dagger\ (19)$$

Maximum moment

$$= \frac{w}{3}\sec^2 a \left(\frac{e^2}{3}\right)^{\frac{3}{2}} = .0641\,w e b^2 \qquad \dagger (20)$$

CASE II. B.—Slant surface; both supports below water (Fig. 8).

$$R_1 = \frac{w \sec a}{6}(e^2 + e\,a - 2\,a^2)$$
$$= \frac{w \sec a}{6}(e - a)(e + 2\,a)$$
$$= \frac{w\,b}{6}(e + 2\,a) \qquad \dagger\ (21)$$

$$R_2 = \frac{w\,b}{6}(2\,e + a) \qquad \dagger\ (22)$$

The bending moment at a distance x below water surface is

$$M = \frac{w}{6}\sec^2 a[(e^2 + e\,a + a^2)x - x^3 - e\,a\,(e + a)]$$

For a maximum, $x = \sqrt{\frac{e^2 + e\,a + a^2}{3}}$

and $$d = \sec a\,(e - x) = \sec a\left[e - \sqrt{\frac{e^2 + e\,a + a^2}{3}}\right] \dagger (23)$$

The above value of x substituted in the formula for bending moment gives

Maximum moment

$$= \frac{w}{6}\sec^2 a\left[2\left(\frac{e^2 + e\,a + a^2}{3}\right)^{\frac{3}{2}} - e\,a\,(e + a)\right] \qquad \dagger\ (24)$$

CASE III.—Vertical surface; top support above water level (Fig. 9).

$$P = \text{total pressure} = \frac{w\,e^2}{2}$$

$$R_1 = \frac{w\,e^2}{6\,c} \qquad (25)$$

$$R_2 = \frac{w\,e^2}{6\,c}(3\,c - e) \qquad (26)$$

The bending moment at distance x from the bottom is

$$M = \frac{w}{6}\left[\frac{e^3}{c}(c - x) - (e - x)^3\right]$$

For a maximum $\frac{d\,M}{d\,x} = o$

whence

$$x = d = e - \sqrt{\frac{e^3}{3\,c}} \qquad (27)$$

and

$$\text{Moment} = \frac{w\,e^3}{6}\left(1 - \frac{e}{c} + \frac{2\,e}{3\,c}\sqrt{\frac{e}{3\,c}}\right) \qquad (28)$$

CASE IV.—Vertical surface with some reverse pressure (Fig. 10).

In this case the actual pressure diagram is the trapezoid $A\,B\,C\,D$. There are therefore three sets of results, depending on whether the point of maximum moment occurs at, above, or below the point A.

The criterion is discovered as follows: Suppose the point of maximum moment falls at A. From a well-known law of mechanics, the shear at a point of maximum moment is zero, so that the shear at A is zero.

Then $$R_2 = w\,b\,e_1$$

but

$$R_2 = w\,b\,e_1\frac{a_1 + e_1/2}{a_1 + e_1} + \frac{w\,b^2}{2}\frac{a_1 - b/3}{a_1 + e_1}$$

whence

$$e_1 = \sqrt{b\left(a_1 - \frac{b}{3}\right)} = K^1 \qquad (29)$$

This is the criterion.

When $e_1 = K^1$, the maximum moment is at A, and Case IV. A applies.

When $e_1 < K^1$, the maximum moment occurs above A, and Case IV. B applies.

When $e_1 > K^1$, the maximum moment occurs below A, and Case IV. C applies.

IV. A.—The point of maximum moment is at A.

$$R_1 = \frac{w\,b^2}{2} \qquad (30)$$

$$R_2 = w\,b\,e_1 \qquad (31)$$

d = (height of point of maximum moment above bottom) $= e_1 = \sqrt{b\left(a_1 - \frac{b}{3}\right)}$ (29)

$$\text{Maximum moment} = \frac{w\,b\,e_1^2}{2} \qquad (32)$$

IV. B.—The point of maximum moment falls above lower water surface, i.e. $e_1 < K^1$ (Fig. 11).

$$R_1 = \frac{w\,b}{2\,c}\left(\frac{b^2}{3} + e\,e_1\right) \qquad (33)$$

$$R_2 = \frac{w\,b}{2\,c}\left[b\left(a_1 - \frac{b}{3}\right) + e_1(2\,a_1 - e_1)\right] \qquad (34)$$

The bending moment at a section at height x above the lower water surface is

$$M = \frac{w\,b}{2\,c}\left(\frac{b^2}{3} + e\,e_1\right)(a_1 - x) - \frac{(b - x)^3}{6}$$

To make this maximum,

$$x = b - \sqrt{\frac{b\,K}{c}}$$

$$d = e_1 + x = e - \sqrt{\frac{b\,K}{c}} \qquad (35)$$

$$\text{Max. moment} = \frac{w\,b\,K}{2\,c}\left(a + \frac{2}{3}\sqrt{\frac{b\,K}{c}}\right) \qquad (36)$$

where $K = e_1^2 + e_1\,b + \frac{b^2}{3}$

IV. C.—When $e_1 > K^1$ i.e. the point of maximum moment falls below lower water surface, (Fig. 12).

$R_1 =$ } Same as IV. B. Eq. (33) and (34).
$R_2 =$ }

The bending moment at a height x above the bottom is

$$M = R_2\,x - \frac{w\,b\,x^2}{2}$$

To make this maximum,

$$x = d = \frac{1}{2\,c}\left[b\left(a_1 - \frac{b}{3}\right) + e_1(2\,a_1 + e_1)\right] \qquad (37)$$

Maximum moment

$$= \frac{R_2^2}{2\,w\,b} = \frac{w\,b}{72}\left[\frac{b\,(3\,a_1 - b) + 3\,e_1(2\,a_1 + e_1)}{c}\right]^2 \qquad (38)$$

If in Case IV. the higher water surface comes up to R_1, make $b = a_1$ and use above formulas.

The formulas for the eight cases, I. A to IV. C, are tabulated on the following page.

In figuring a Stoney or other rolling lift gate it is convenient to have an expression for the proportion of water pressure taken by each of the horizontal cross beams. In Fig. 13 is shown a gate having four horizontal beams. Using the notation there shown, the loads per horizontal running foot are:

Load on beam A

$$\frac{w\,a^3}{6\,f} \qquad (39)$$

Load on beam B

$$= \frac{w}{6}\left[3\,a^2\left(1 - \frac{a}{3\,f}\right) + d\,(b + 2\,a)\right] \qquad (40)$$

Load on beam C

$$= \frac{w}{6}\left[d\,(2\,b + a) + e\,(c + 2\,b)\right] \qquad (41)$$

Load on beam D

$$= \frac{w\,e}{6}(2\,c + b) \qquad (42)$$

Formula (41) can be applied to any number of intermediate beams.

Formulas (39) to (42) are obtained directly from (13), (14), (25) and (26).

If the water surface is at the top of the gate (at A) then formula (39) becomes

$$\frac{w\,f^2}{6} \qquad (39')$$

and formula (40) becomes

$$\frac{w}{3}\left[f^2 + \frac{d}{2}(b + 2\,a)\right] \qquad (40')$$

If the water surface is above the top of the gate the load on B may be obtained from formula (21).

Numerous approximate formulas have been proposed for the thickness of steel plate subjected to water pressure as in a ship or a head or waste gate.

We shall show a method of procedure in designing such gates which, notwithstanding several approximations, gives fairly correct results.

In designing a Stoney, rolling lift, or Tainter gate it is convenient to assume a spacing for the horizontal beams or girders and also a thickness of plate.

The problem is then to determine the maximum spacing of stiffeners for the assumed thickness of plate. Assume that in any direction the plate acts as a continuous beam. Assume also that the maximum deflection and therefore the maximum stress occurs in a horizontal plane at the center of pressure of the water supported by the rectangular plate area between supports.

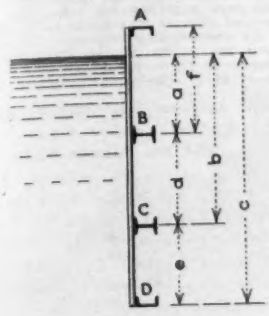


Fig. 13.

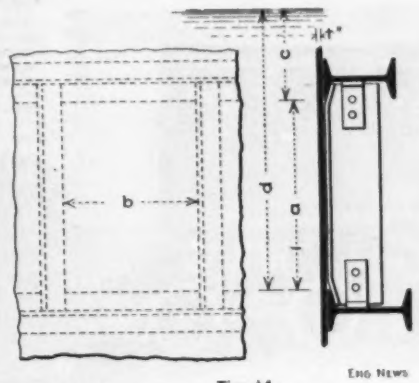


Fig. 14.

Employing the following symbols (Fig. 14):

s = safe stress in plate, in lbs. per sq. in.

t = thickness of plate, ins.

a = clear distance between beams, ins.

b = clear distance between stiffeners, ins. (to be found).

w = weight of water, lbs. per cu. ft.

The distance of the center of pressure below the water surface is

$$d = \frac{a}{2}\left(\frac{a+3c}{a+2c}\right)$$

At this point the pressure per sq. ft. is

$$W = w\,d - \frac{w\,a}{3}\left(\frac{a+3c}{a+2c}\right)$$

The moment at this point, on a horizontal strip one inch wide, is

$$M = \frac{W}{144}\,\frac{b^2}{12}$$

The section modulus of this strip is $\frac{t^2}{6}$; therefore

$$\frac{W}{144}\,\frac{b^2}{12} = \frac{t^2 s}{6}$$

whence

$$b = 12\,t\sqrt{\frac{2\,s}{W}}\ \text{(in inches)} \qquad (43)$$

If $s = 16{,}000$ lbs. per sq. in.

$$b = 2146\,7\,\frac{t}{\sqrt{W}} \qquad (43^1)$$

When $a < 2\,b$ it is desirable to assume the total panel load divided as follows:

Part taken by stiffeners : Part taken by beams :: $a^4 : b^4$, since the plate deflection, and stress, varies inversely as the fourth power of the span.

When, as is usually done, gates are designed for a maximum flood which may occur only once or twice in the life of the gate, the above formula applies. For other conditions different assumptions should be made.

In conclusion the writer wishes to acknowledge his indebtedness to Mr. W. B. Allen for checking these formulas.

TUNNEL HEADINGS FAILED TO MEET BY 8 FT. on a tunnel being driven by the Union Pacific R. R. in Tacoma, Wash., according to a recent newspaper item. Such occurrences, however, are so extremely rare that we question the reliability of the item.

OPEN HEARTH STEEL RAILS FOR THE PANAMA R. R.—A shipment of 1,300 gross tons of open hearth steel rails manufactured by the Bethlehem Steel Co. arrived at Cristobal last week. The consignment is composed of 1,000 gross tons of 70-lb. rails and 300 gross tons of 90-lb. rails. The new 90-lb. rails will be used on the sharp curves between Las Cascadas and Tabernilla to replace the 90-lb. Bessemer steel rails that have been in use on these curves. Owing to the heavy traffic on this section of the railroad the 90-lb. Bessemer rail has been worn out in from ten to twelve months. The chemical composition of the open hearth rail is as follows:

	70-Lb. Per cent.	90-Lb. Per cent.
Carbon	.65— .75	.70— .80
Phosphorus, shall not exceed	.035— .04	.035— .04
Silicon, shall not exceed	.20	.20
Manganese	.80—1.05	.80—1.05

The uniformly high temperature of the climate on the Isthmus is especially favorable for the use of the high carbon rail and it will give excellent service on account of its hardness.—"Canal Record," May 5.

THE LIDGERWOOD CABLEWAYS for the construction of the Gatun locks are nearing completion. The "Canal Record" of May 5 stated that all the towers for the unloading cableways were completed and the cables and machinery were rapidly being placed. The eight concrete mixers were in place and seven of the eight towers for the cableways spanning the lock pit were erected. At Pedro Miguel material is to be handled by cranes and ten narrow-gage locomotives have been delivered which will haul concrete from the mixers to the cranes, which will place it in the lock chambers.

COST OF REINFORCED-CONCRETE BUILDINGS.—"Regarding the cost of reinforced-concrete construction as compared with other types, the large use has proved conclusively that it will compete, because the item of cost is considered paramount in 99 out of every 100 structures. For large buildings the structural frame is almost always cheaper than the steel. Thin curtain walls cannot be built as cheaply on account of form work, which is constant for thin and thick walls, but if the wall must be 16 ins. or more in thickness concrete is cheaper than brick. In small structures, such as dwelling houses, concrete is materially more expensive than brick or wood, because the form work is more irregular and cannot be used over, and because of the greater expense of supervision. This is why it is not commonly used in small dwellings, and probably will never be much used. It has been used and can be economically used for large dwelling houses, especially those of simple design, where the form work is nearly as easy of execution as in an office building or mill."—L. C. Wason, in "Reinforced Concrete as a Fireproof Building Material," before Natl. Fire Protection Assn.

SUMMARY OF REACTIONS AND MAXIMUM MOMENTS OF VARIOUS GATE OR NEEDLE BEAMS.

Case.	Description.	Upper reaction R_1.	Lower reaction R_2.	Height of point of maximum moment above R_2.	Maximum moment.
I. A	Vertical surface. One support at surface of water (Fig. 5).	$\frac{w\,c^3}{6}$	$\frac{w\,c^3}{3}$	$0.423\,c$	$0.0641\,w\,c^3$
I. B	Vertical surface. Both supports below water surface (Fig. 6).	$\frac{w\,c}{6}(e+2a)$	$\frac{w\,c}{6}(2e+a)$	$e\sqrt{\frac{e^2+ea+a^2}{3}}$	$\frac{w}{6}\left[2\left(\frac{e^2+ea+a^2}{3}\right)^{\frac{3}{2}} - ea(e+a)\right]$
II. A	Slant surface. One support at surface of water (Fig. 7).	$\frac{w\,e^3\sec\alpha}{6}$	$\frac{w\,e^3\sec\alpha}{3}$	$0.423\,e$	$0.0641\,w\,e\,b^3$
II. B	Slant surface. Both supports below water surface (Fig. 8).	$\frac{w\,b}{6}(e+2a)$	$\frac{w\,b}{6}(2e+a)$	$\sec\alpha\left[e-\sqrt{\frac{e^2+ea+a^2}{3}}\right]$	$\frac{w}{6}\sec^3\alpha\left[2\left(\frac{e^2+ea+a^2}{3}\right)^{\frac{3}{2}} - ea(e+a)\right]$
III.	Vertical surface. Top support above water level (Fig. 9).	$\frac{w\,e^3}{6\,c}$	$\frac{w\,e^2}{2}\left(1-\frac{e}{3c}\right)$	$e-\sqrt{\frac{e^3}{3c}}$	$\frac{w\,e^3}{6}\left(1-\frac{e}{e}+\frac{2e}{3c}\sqrt{\frac{e}{3c}}\right)$
IV. A	Vert. surface with reverse pressure. Point of max. mom. at lower water surface (Fig. 10).	$\frac{w\,b^2}{2}$	$w\,b\,e_1$	e_1	$\frac{w\,b\,e_1^2}{2}$
IV. B	Vert. surface with reverse pressure. Point of max. mom. below water surface (Fig. 11.)	$\frac{w\,b}{2c}\left(\frac{b^2}{3}+e\,e_1\right) = \frac{w\,b}{2c}K$	$\frac{w\,b}{2c}\left[b\left(a_1-\frac{b}{3}\right)+e_1\left(2a_1+e_1\right)\right]$	$e-\sqrt{\frac{b\,K}{c}}$	$\frac{w\,b\,K}{2c}\left(a+\frac{2}{3}\sqrt{\frac{b\,K}{c}}\right)$
IV. C	Vertical surface with reverse pressure. Point of max. mom. below lower water surface (Fig. 12).	$\frac{w\,b}{2c}\left(\frac{b^2}{3}+e\,e_1\right) = \frac{w\,b}{2c}K$	$\frac{w\,b}{2c}\left[b\left(a_1-\frac{b}{3}\right)+e_1\left(2a_1+e_1\right)\right]$	$\frac{1}{2c}\left[b\left(a_1-\frac{b}{3}\right)+e_1\left(2a_1+e_1\right)\right]$	$\frac{w\,b}{72}\left[\frac{b\,(3a_1-b)+3e_1(2a_1+e_1)}{e}\right]^3$

A Side-Rod Electric Locomotive.*

A peculiar type of experimental electric locomotive, designed jointly by the General Electric and American Locomotive companies, is shown in Figs. 1 and 2. Power is transmitted to the drivers through an arrangement of side rods, instead of by the common gearing.

It was believed, in developing this design, that the number of motors could be reduced with consequent increase in size and efficiency. Small driving wheels can be used and the interchange of motor equipment between passenger and freight engines is expected to be possible. This design concentrates more weight near the vertical axis of the locomotive. It is expected thus to reduce the rail pressures at the leading and trailing trucks and consequently rail and flange wear.

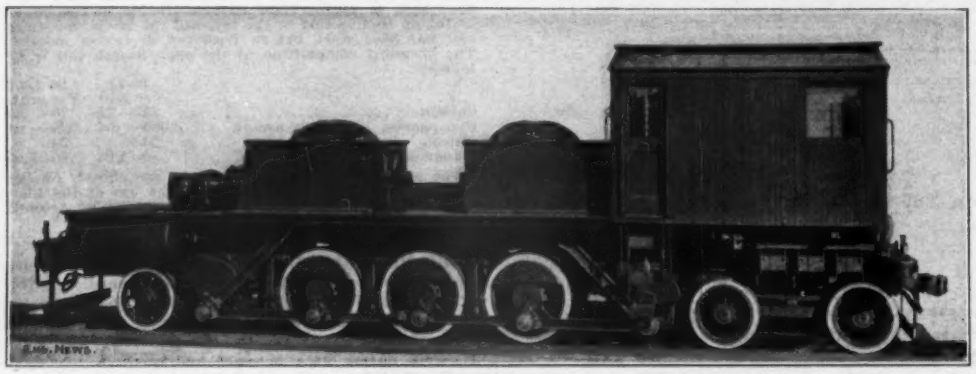


FIG. 1. 1,600-HP. SIDE-ROD ELECTRIC LOCOMOTIVE.
(Designed by the General Electric and American Locomotive Companies.)

The design of the running gear follows standard locomotive practice so far as possible. Each motor is coupled to a jack shaft through long inclined rods. The jack-shaft bearings are rigid in the spring-supported frame and have their centers normally on a level with those of the driving wheels. This jack shaft permits a horizontal drive between the spring supported part of the locomotive and the driving wheels and was found necessary to secure a vertical play of the spring supported parts with a negligible variation in the distance between crank centers.

This experimental engine is now equipped with single-phase alternating-current motors, though the design is also adapted to direct-current driving. The whole of the cab has not been built over the frame as yet. The locomotive is designed to give a tractive effort of 33,000 lbs. at 18 mi. per hr., and to permit a maximum speed of 50 miles per hour. The motors now used in this trial equipment start as repulsion motors, with short-circuited armatures, and are changed over to series repulsion motors at the higher speeds. This allows a high starting torque and avoids having the armature short-circuited at high voltages.

Fig. 3 shows, partly assembled, a flexible coupling inserted between the armature shaft of the motor and the motor crank. A series of leaf springs are radially disposed about the former and drive the latter. The springs are designed to carry the maximum motor torque with such deflection as will reduce the pulsations of torque in a single-phase alternating-current motor.

The principal dimensions are tabulated as follows:

Diameter of driving wheels	49 ins.
Number of driving wheels	6
Diameter of pony wheels	36 ins.
Diameter of bogie wheels	36 ins.
Total wheel base	33 ft. 6 ins.
Rigid wheel base	10 ft.
Length, total	43 ft. 6 ins.
Height	13 ft. 8 ins.
Weight on drivers	162,000 lbs.
Weight per axle, driving	54,000 lbs.
Total weight	250,000 lbs.
Trolley voltage	10,000
Cycles	15
Rated tractive effort	33,000 lbs.
Speed at rated amperes	18 m. p. h.
Total HP.	1,600
Number of motors	2

*From information furnished by the General Electric Co., Schenectady, N. Y.

The Salette Landslide of 1908 and Some Earlier Quebec Landslides.

Landslides along rivers are more or less frequent occurrences in the province of Quebec. Certain clay deposits occurring there seem to be peculiarly prone to slides. The phenomena of such slides are often very surprising. By no means their least important feature is that they come without premonitory symptoms, so that there is no warning to those who may be overwhelmed. Special interest, therefore, attaches to investigations and studies of the slides. It must be said, however, that almost the only result which such studies have produced so far is the recognition that a region in which traces of past slides may be found is a very likely region for more slides.

The latest of the Quebec landslides produced the largest loss of life, though it was a relatively small one. It occurred on April 6, 1908, at Chalifoux Landing, on the west bank of the Lièvre River, opposite the town of Notre Dame de la Salette, Labelle Co., Quebec, some 30 miles northeast of Ottawa. As far as can be ascertained 33 persons were killed. Five years before a much larger slide occurred on the same River, about six miles downstream, at Poupore. The Poupore slide and three others which have occurred in Quebec province are described below, together with the Salette slide.

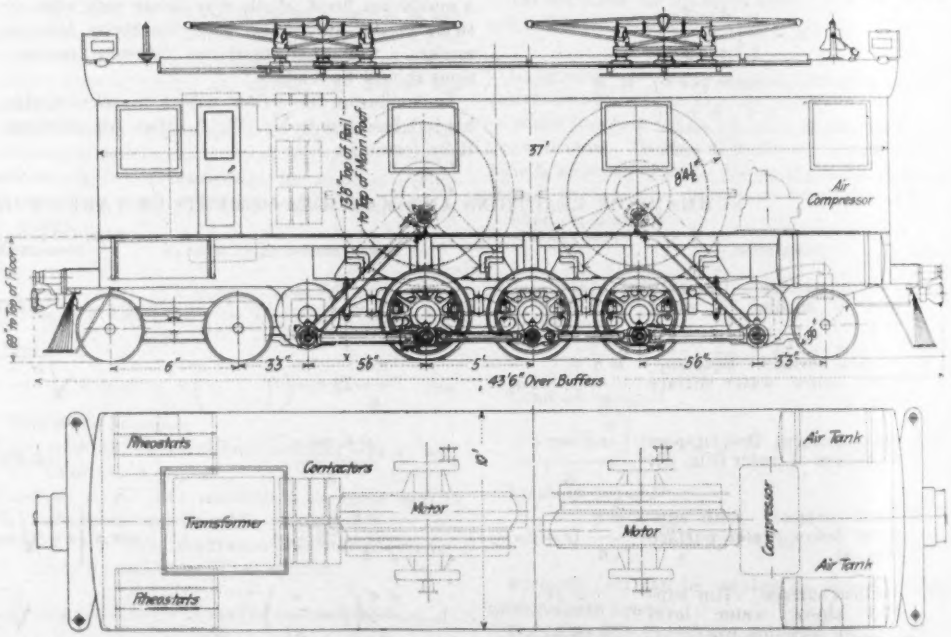


FIG. 2. PLAN AND ELEVATION OF EXPERIMENTAL SIDE-ROD ELECTRIC LOCOMOTIVE.

Mr. R. W. Ells, of the Department of Mines of Canada, visited the Salette slide and reported his observations, which have been published in a recent bulletin of the Department. He reported also on the Poupore slide, while the others were studied by different observers.

The five slides are noted below in the order of date; most of the material is ta[illegible] from Dr. Ells' report on the Salette slide.

The Maskinonge Slide.

April 4, 1840, a peculiar slide occu[illegible] in Maskinonge Co., Quebec, an the bank [illegible] the Maskinonge River, a short distance no[illegible] of the St. Lawrence. Sir W. E. Logan, who [illegible]amined it, gives the area as 84 acres. It was [illegible] a spalling off or sliding of a segment of the [illegible]k, but like a pouring out of the upland throu[illegible] a narrow gap in the bank.

The chasm is described as oblong in [illegible]pe, with a narrow funnel-like end toward the riv[illegible]. The total length was about 1,300 yds., while the [illegible]dth varied the widest part equalling 600 yds. The [illegible]tom of the widest part of the pit was found to be 3[illegible] below the level of the surrounding country. The [illegible]rial transported into the valley of the Maskinong[illegible] River filled it to a depth of 75 ft. for a mile and a [illegible]f. [Quoted from Report of R. Chalmers, Geological [illegible]rvey.]

No rock surface was exposed on which the slipping might have taken place.

The St. Albans Slide.

Four miles above St. Albans, Portneuf Co., Quebec, on the River Ste. Anne de la Pérade, a small stream flowing into the St. Lawrence from the north, an enormous slip occurred on April 27, 1894. Some 3½ mi. of the west bank slipped into the river, permanently changing its course. The movement seemed to be in three stages. The northerly end slipped first, with a depth of some 10 ft. A few hours later the part south of this slid down, and finally the material below the second slide also went out, making the total depth here 175 ft. The average depth of the whole chasm was at least 100 ft. below the general ground surface, and its width about a mile.

The Rivière Blanche Slide.

Seven miles from the last-named, but on a different stream, the Rivière Blanche (tributary of the Ste. Anne de la Pérade), a slide similar to the Maskinonge slide occurred on May 7, 1898. A description will be found in our issue of March 15, 1900, p. 175. The location is in St. Thuribe parish, Portneuf Co., Quebec. The slide was about 3,000 ft. long at right angles to the river, 1,700 ft. wide at its widest point, and up to 30 ft. deep; it had only a narrow opening on the river. The volume of earth moved was at least 3,000,000 cu. yds. The front of the bank first gave way, for a length of 200 ft., and from here the caving extended inland, widening a short distance behind the bank. The whole body of clay embraced in the slide rushed out through the opening, spreading upstream in the river valley some 500 ft. and downstream nearly 2 miles. The floor of the depression left by the slide was irregular, with mounds of clay, pools of water, and trees, fences, etc.; its slope was very flat, being about 27 ft. on the whole length, or less than 1%.

Adjoining this slip to the north was a de-

pressed [illegible], under cultivation, marking the site of a much earlier slide. North of this again is a low ridge of boulder clay; the rest of the river plain is Leda clay and Saxicava sand.

At the [illegible] of the 1898 slide, a small water course entered the valley, and here a small slip was observed on the evening previous to the large slide, but no attention was paid to it. At 5.30 the next morning, more extensive slipping began at the same point and the movement rapidly spread backward, expanding laterally at the same time. Dr. R. Chalmers says:

The soft material flowed out from beneath, while the upper and more coherent clay split off in vertical sheets and columns which were borne away in the sliding, surging mass. This continued for upwards of three hours, when the transporting power seemed to have spent itself, and great masses of clay which had become detached from the walls of the chasm stranded in its bottom.

The marine deposits in which this landslide occurred are quite arenaceous and silty, and no well-defined break was seen to exist between the Saxicava sand and Leda clay, the one graduating into the other.

Specimens of the clay in nearly saturated condition showed a mean specific gravity of 1.91, equivalent to a weight of 119.5 lbs. per cu. ft. It consisted of 35.5% argillaceous matter, 43.3% sand, and 21% water, and was capable of absorbing some 2% more water.

The snow, which was very deep the preceding winter, melted in April, so that early in May, when the slide occurred, the ground was well saturated.

Mr. Chalmers likens this slip to the bursting of a reservoir of water.

The Poupore Slide.

At Poupore on the Lièvre River, in Labelle Co., Quebec, a large slide occurred on Oct. 11, 1903. The west bank slipped northeastward into the river, the movement including an area of 95 acres extending nearly half a mile back from the bank, in fact back to a hill or mountain. Its depth was about 20 ft. below the original ground level. The area had not been disturbed by slides previously. The clay filled the river channel for about three-fourths of a mile, and even filled a lock (Little Rapid lock), a short distance upstream, in a canal on the east bank.

According to Dr. Ells, the Poupore slide occurred after heavy rains lasting for several days. The clay and silt east of the mountain became saturated. At the junction of the clays with the rock of the mountains, there was a layer of broken rock, through which the drainage from the hill percolated. He asserts that a layer of silt 15 or 20 ft. below the surface received this percolation and, becoming saturated, passed into the semi-liquid condition. Though the slope to the river bank was very gradual, the weight of the clay mass finally sufficed to start a movement on this slip layer.

The amount of displacement measured at several points on the flat itself, seemed, as could be seen by the displaced road which traversed the area, to be about 300 ft. as a maximum. The movement was not along the smooth glaciated surface of the underlying rocks, but merely along the silt planes in the clay itself.

The description makes it appear that the surface layer retained much of its tenacity and did not participate in the flow except as it settled with the effluxion of the softened mass below and was dragged along partway. The same thing seems to have been the case in some of the other slides mentioned above.

The Salette Slide.

Last year's slide at Chalifoux Landing was distinguished by its unusual violence, though its area was small. The west bank was a clay bluff some 60 ft. above the river. A crescent-shaped portion, 1,300 ft. long along the edge of the bank and 400 ft. wide slid out suddenly, fell upon the ice which still covered the river unbroken, and projected the ice forward and upward upon the low east bank, where it destroyed the settlement of Notre Dame de la Salette. A house which stood on the area of the slide contributed three or four of the victims.

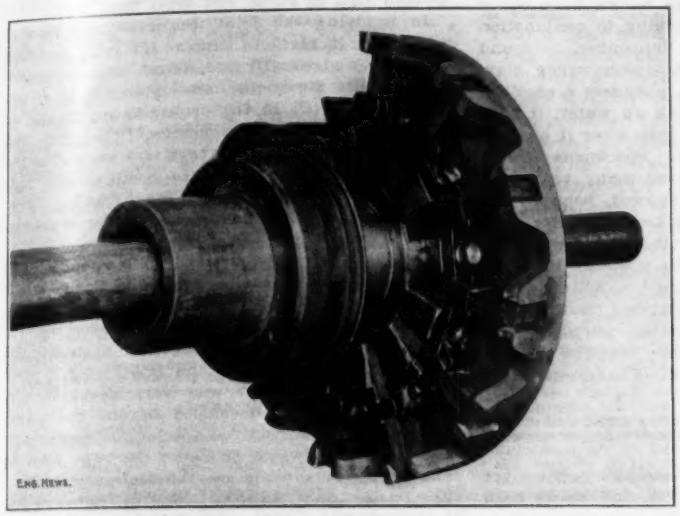


FIG. 3. FLEXIBLE COUPLING FOR SINGLE-PHASE TRACTION MOTOR.

Dr. Ells describes the slide as follows:

The Salette slide is comparatively narrow. . . . The length of the slide . . . along the bank of the stream is about 20 chains, or say 1,350 ft. The line of the break is irregular, extending inland at the widest part about 400 ft., as nearly as can be now estimated, and the area involved in the slide is apparently not far from six acres. The height of the clay bank which slipped into the river was about 60 ft. above the present level of the stream.

. . . . . .

The actual cause of the slide appears to have been a fissure, into which the water descended until it reached an underlying portion or stratum of blue clay which, along the edge of the break, had an exposed dip towards the river of 18 to 20°—when the overlying burden of clay, silt and sand overcame the resistance and slipped forward into the river bed. The momentum of this sliding mass, starting from an elevation of 60 ft., and at such a short distance from the front of the bluff, must have been very considerable and the movement correspondingly rapid.

The ice in the river was apparently unbroken at the time, and was lifted and carried forward over the east bank on which Salette village was located, at an elevation of not more than 12 to 15 ft. above the present level of the river, which was some feet above the ordinary summer level. The rush of the ice came with such force against the village as to completely demolish the greater portion. In fact, everything within its course was destroyed, including 12 houses and some 25 outbuildings, which were entirely destroyed to their very foundations; while on the margin of the ice movement several other buildings were more or less damaged.

The rush of ice was followed by a rush of water from the river, which carried portions of the ruined buildings and the bodies of villagers inland beyond the road which is parallel to the shore, depositing the débris at an elevation of about 50 ft. above the river level. The receding wave swept backward over the village site with sufficient force to remove the greater part of the ice above, as well as the greater portion of the débris of the village itself; though scattered ice-blocks could be found several days after the disaster. All this débris was swept down the river, together with a number of bodies, which had probably been entangled in the ruins, and carried away in the same movement, proved by the finding of several corpses as far down as Buckingham village. Of the number of persons who lost their lives in this distressing calamity, not more than half could be accounted for. Of the missing, some have probably been buried in the roughly piled masses of clay or mud along the river bed, with which the channel was choked; while others have been swept downstream, and may be engulfed in the numerous eddies along the river.

. . . . Had the ice not been present, doubtless the rush of the water would have damaged and possibly destroyed some of the smaller buildings nearer the water, but would not have wrought such wholesale destruction, and probably would have left a larger amount of the clay upon the east bank, much of which must have been kept in check by the overlying ice-mass. The width of the channel at this place, as measured in the survey of the district some years ago, is between 250 and 300 ft. The residents in the houses engulfed on the west side were probably caught in the sliding clays and silts. Several persons were rescued when nearly lifeless from smothering, and exposure to the icy waters.

The unstable nature of the material composing the bluff which fell, can be seen in the close admixture of blue clay and sandy silts in the beds deposited. On the second day after the disaster, portions of the bank were still falling in considerable amount, the upper portion breaking off in masses sufficient to move forward over the débris to a distance of 100 to 150 ft. until stopped by the rough surface of that already fallen. At the time of our visit, it was practically impossible—owing to the unstable condition of the edge of the break—to approach near enough to make an accurate survey of the locality.

. . . . . .

It does not appear to be possible to adopt any special methods to prevent these disasters. The simplest method to prevent loss of life seems to be to prevent the placing of buildings near the front of bluffs or shores where the unstable clay deposits are liable to be affected by the conditions already indicated.

The last recommendation, however, would be ineffective to protect against slides which extend back from the bank rather than laterally, as the Maskinonge and Rivière Blanche slides.

It remains to add that, according to Dr. Ells, the Lièvre River has been subject to landslides for a long time, in the region of the clay banks which line its shores to nearly 30 miles north of the St. Lawrence. The hummocky surface of former slides may be recognized readily, though often under cultivation, or even covered by a growth of timber. In such places the clay deposits have been broken up, are mixed with silt and surface soil, and frequently contain large sheets of clay with steep inclination. In such recomposed deposits, the remains of forest trees buried at the period of the original slide can occasionally be seen projecting from the face uncovered by a more recent slide.

The rock hills which border the valley show smooth, glaciated faces at some places, indicating that in the glacial period the ice followed down the valley. The clays, where undisturbed, are deposited in heavy beds, substantially horizontal, separated by thin layers of arenaceous silt. The clay is usually homogeneous, bluish in color, tough, and plastic under action of water. The silty layers, when saturated, suddenly pass into semi-liquid condition.

The five Quebec slides above described differ in several characteristic features from slides elsewhere. None of them were on steep slopes, but all occurred on flat tablelands bordering a river and standing 20 to 60 ft. above the surface of the stream. In every case the bottom of the cavity which they left showed an exceedingly flat slope, though not a smooth surface, being roughened by blocks or masses of undisintegrated clay, probably pieces of the surface layer. Further, in no case is there a report of gradual motion preceding the caving, but the mass seems to have been stationary and apparently as firm as ever, until the rapid flow began. The bottle-shaped slides, as at Maskinonge and Rivière Blanche, are again sharply distinct in external appearance from such slides as the Salette, but in all of them the evidence is unmistakable that the strata below the surface were very much softened, in fact were reduced to a condition of extreme plasticity. The depths of the slides are not more than 15 ft. in one or two of the cases, and at this depth the superincumbent strata, at 120 lbs. per cu. ft., would constitute a load of less than one ton per sq. ft. Even at half this depth the plasticity must have been very marked, i. e., the clay was in such a state that a load of 900 lbs. per sq. ft. was sufficient to produce lateral flow, and that, too, with sufficient intensity to exert the necessary pseudo-hydrostatic pressure for bursting out the face of the bank.

It may be only a coincidence that the five slides noted were all of them small streams flowing into the St. Lawrence from the north, and within a distance of 10 to 20 miles of the latter river. However, they are not close together; the Lièvre slides are no less than 100 miles west of the Maskinonge, while the slides of Rivière Blanche and Ste. Anne de la Pérade are 50 miles east of that point. The alluvial clay deposits

concerned seem to be substantially the same in the five cases. The part played by excess of water and imperfect drainage is evident.

Some notes on slides caused by water under entirely different conditions, namely the softening action of irrigation water on clay beds of peculiar physical nature in a dry region, were given by Mr. H. J. Cambie in a paper printed in our issue of Jan. 8, 1903, p. 38. Troublesome slides of the more common slow-sliding or creeping type are noted in Eng. News, March 23, 1893, p. 268 (on Bolan Ry. in India), Dec. 6 and 20, 1894, pp. 459 and 503 (Tacoma, Wash.), and April 30, 1908, p. 478 (on Big Four Ry. near Homestead, Ohio). The great slide at Frank, Alberta (Eng. News, June 4, 1903, pp. 490-492) was of entirely different character, involving a rock mountain.

Irrigation Landslides on the Thompson River, British Columbia.

The slides referred to by Mr. Cambie occurred on the banks of the Thompson River in British Columbia. They were described at some length in a paper read before the Institution of Civil Engineers (England) by Mr. Robert B. Stanton in 1897, under the title "The Great Landslides on the Canadian Pacific Ry. in British Columbia." A brief reference may be made to them here.

There are many slides within the distance of a few miles, most of them being along the east bank, just south of the town of Ashcroft. The largest of them is now quiescent:

> The great north slide happened in October, 1881. Irrigation had been carried on above it for some years, and some time before the final catastrophe occurred a reservoir 2 mi. distant in the hills, from which the irrigation water came, broke its dam and most of the water liberated spread over the upper benches of this land, already well soaked. The whole tract of 150 acres sank vertically in one movement to a depth, at the back edge, of over 400 ft. The lower portion, about 2,000 ft. wide, was forced entirely across the river, a distance of 800 to 1,000 ft., and coming against the steep bluff on the opposite side it filled the whole inner gorge of the valley, and formed a dam fully 100 ft. high, completely stopping the flow of the river for several days, so that men walked dry-shod across the river-bed below the dam. The Thompson River carries in the autumn 15,000 to 20,000 cu. ft. of water per sec. The dam formed a lake over 12 mi. in length, which is roughly estimated to have contained 7,000 million cu. ft. of water. As soon as the water rose above this dam of loose broken material it was swept away, and caused a terrific flood in the valley below.
>
> All the arable land above the north slide was carried down by the first break, and hence irrigation was stopped at that point. After some years the water drained out so completely that the movement practically ceased and the land became again stable. The railway crosses this slide 500 or 600 ft. back from the river, and since the water has drained out little trouble has been experienced, for the land has settled firm and dry.

Another, but much smaller, slide simulated some of the Quebec slides in its fluid-like forward movement:

> At Spence's Bridge, some miles down the river, a slide occurred from the same cause on the west side of the river. It crossed entirely over the stream and deposited a number of acres of land on the east side of a bench 25 ft. above the river, between it and the railway, covering an Indian burying-ground.

As to the cause of these slides, Mr. Stanton, after examining all the possible causes, concludes that the irrigation water used on the upper benches of the high valley bottoms is responsible. One of his strongest reasons for this view is the fact that the North Slide carried away the irrigable land above, so that subsequently there was no irrigation water draining to it, and that the slide became quiescent. He further argues:

> By the testimony of Indians who had lived in the country all their lives and that of some of the original white settlers, no slides had ever occurred at any point along the Thompson River before the white men began to irrigate the land, although one or two small cave-downs existed before that time. In every instance noted, these slides occurred between 3 years and 6 years after irrigation began at each point. In the case of the largest one, the great north slide, the final catastrophe was hastened by the bursting of the reservoir. A very large amount of water was necessary for raising crops, on account of the sandy nature of the soil and the nature of the subsoil. The topography of the several benches assisted materially toward the final result. Each field being in the form of a shallow basin, around which the irrigation ditches were built, little of the surplus water was drained off, hence the greater part of that not taken up by the plants or evaporation ran towards the center of the field and soaked down in one channel.
>
> * * * The silt or imperfect clay, which lies in masses between 200 ft. and 1,000 ft. in thickness, is generally fine and of uniform texture, and usually well bedded in horizontal layers of from ¼-in. to 3 or 4 ins. thick. In its natural state it is hard and dry, like a soft sandstone, and when held between the fingers and struck with a light hammer rings like stone. A large piece of this silt, however, placed in a basin of water dissolves after a few minutes and falls down, not in a lump as clay, but it mingles with the water, forming a semi-fluid mass like thick pea-soup.

According to tests, this melting takes place when 78.5% water has been absorbed. But in the steep river-bank bluffs this same substance stands up firm and resistant, which seems to disagree with the above description. In its constitution the material is a mixture of silica sand, broken feldspar and decomposed feldspar. Mr. Stanton believes that running water washes out the gritty elements (the two first mentioned), leaving only the clayey decomposed rock, which forms an impervious coating on the surface and protects the interior from the water.

Mr. Cambie, in the paper already referred to, gives another explanation of why the clay and silt layers should soften under the action of irrigation water although they stand up firm and unchanged in the steep river banks, both below and above water level. Working in conjunction with Mr. H. J. Warsap, of Vancouver, he found by experiment that the Thompson valley clay, after it has once been dried, possesses a changed character. If allowed to soak up water, it suddenly melts down to a thin soup after it has absorbed about 60% by weight. Specimens of clay from the side of a railway cut many years old, where the pick marks still showed, behaved exactly the same way when placed in water. On the other hand, similar clay that has never been dried out thoroughly has the property of cohesion even at maximum saturation, and does not melt down suddenly as described, but softens continually until it is a plastic, coherent, soft clay. In fact there is evidence that the distinction is not restricted to the Thompson River clays, for Mr. Cambie says:

> This led to experiments with other clays, and it was found that they all lost their cohesive properties when the moisture was removed.

He suggests that probably the soil in the river bank, at and near water level, had never been fully dried out, and therefore was proof against the melting action of water, whereas the clay in the terraces had been altered by drying, and therefore melted down when sufficient water was supplied. He also suggests that the same actions may account for a number of landslides in the Oldman and Belly River valleys, between Medicine Hat and Crow's Nest Pass, in 1902, which occurred after a season of heavier rainfall than previously recorded in those valleys.

Whether similar actions are connected with the Quebec landslides above described is not known, but it seems very doubtful. The St. Lawrence River country is far from arid (while the Thompson River valley is so dry that irrigation is needed to raise crops), and there is no reason to assume that the subsoil has ever been dry.

On the other hand, the fact seems to be that each of the Quebec slips occurred after a wet period, either heavy rains or slow, long-continued snow-melting. The underlying clays, becoming wetter through the seepage from the surface, might attain such a degree of softness as to crush out laterally under the weight of the overlying strata of soil. However, inasmuch as the topographical conditions surrounding the Quebec landslides are in no way peculiar but are found in many other locations, river valleys as well as other districts, where no similar slipping occurs, the hypothesis is weak.

Phenomena of earth movements are of great interest to the engineer, especially as most of them cannot be foreseen and are very difficult to explain. Their troublesome nature or destructive effects make them worth study. It is desirable that all such phenomena be observed fully and the resulting information placed on record.

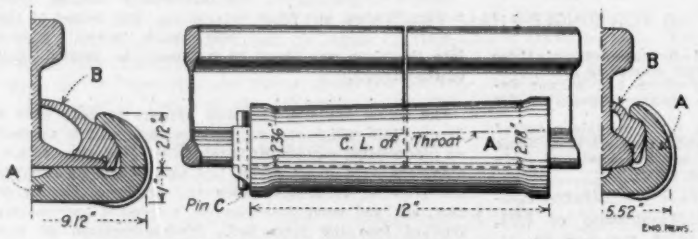
A Rail Joint of the Wedge Type.

Rail joints of the wedge type have been used experimentally in this country and abroad, the purpose being to secure a special strong and permanent joint and to eliminate the usual bolts and nuts. In most cases, the arrangement consists of a channel or trough to receive the rail ends, and two wedges driven between the rail web and the sides of the trough. The accompanying cut represents a joint of the type which is being tried on steam and electric railways in Europe. It is used with double-head rails on the Western Ry. (now a part of the French State Railways) and with tee rails on the Metropolitan Ry., of Paris, and other lines.

In applying the joint, the cast steel channel (A) is set in place to support the rails, and two keys or wedges (B) are driven simultaneously (in opposite directions), one on each side of the rail. A pin (C) in the projecting small end of the key prevents any slackening of the joint. The parts are so designed as to give a very effective grip on the flange (or lower head) of the rail, and the joint can be applied readily and quickly. It is stated that it has been used for repairing broken rails.

In laboratory tests, with the rails supported on bearings 3 ft. 3⅜ ins. apart, center loads of 22 tons (on double-head rails) and 30 tons (on tee rails) have been carried without deflection. A drop test was made with a 570-lb. hammer falling 13 ft. for two blows and 16½ ft. for a third blow. The deflection was very slight, but a crack in the rail developed beyond the joint.

This joint is considered specially advantageous for electric railways, owing to the large area of contact. Tests made on the Metropolitan Ry., at Paris, and on the electric railways of Lausanne (Switzerland) showed good results as to wear and conductivity. In a paper on the Metropolitan Ry. in the April number of the "Revue Generale des Chemins de Fer," by Mr. R. Godfernaux, it is stated that the use of these joints has enabled the copper bonds to be dispensed with at rail joints, thus reducing expense and trouble. There is no difficulty from expansion and contraction, the rails moving freely in the joint.



WEDGE TYPE OF RAIL JOINT IN USE IN EUROPE.

Some of the joints were laid in June, 1907, at a point on the Metropolitan Ry. (Paris) where they carry 300 trains per day; they required no attention for maintenance for a year or more. This line has also two miles of track laid with these joints. In June, 1908, the French State Railways laid the device for about 650 ft. on the Western Ry. line to Versailles, which carries electric local trains and steam main-line trains, with a total of about 110 trains per day. Other railways and electric railways in France, Italy, Switzerland and Belgium are using the device experimentally. The joint is made by the Societe des Eclisses Electro-Mecaniques, 84 Rue de Ranelagh, Paris, France.

UNITED STATES RAILWAYS WITH TRACKAGE IN Canada will hereafter be subject to regulation by the Dominion Government Board of Railway Commissioners. Amendments to the Canadian Railway law were adopted by Parliament on May 12 which makes the law applicable to any railway company operating trains between any point in the United States and any point in Canada.

FOUR DAYS FROM NEW YORK TO SEATTLE is the possible traveling time, by using a new train to be instituted May 23 by the Burlington Route and the Northern Pacific Ry. This train leaves Chicago each day at 9.20 a. m., and traveling via Minneapolis, Fargo, Bismarck, Livingston and Missoula, reaches Seattle, or Tacoma, at 12.30, noon, of the third day. By taking either of the two 18-hour trains out of New York, at 3.30 p. m. (eastern time) a passenger reaches Chicago at 8.30 a. m. (central time) the next morning in time to connect with the trans-continental train, which will get him to the Pacific coast about noon of the fourth day after he left the Atlantic.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Candler Building
REPRESENTATIVES: MOSSE, BERLIN AND HAMBURG, GERMANY
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Entered at the New York Post-Office as Second-Class Matter.

It is generally considered one of the functions of the public press to warn the public against the fraudulent enterprises which are perennially springing up to mislead and dupe credulous investors. The newspaper press, however, is hardly to be relied upon for this work. Most newspapers at the present day are more anxious to exploit sensations than they are to present facts; and the fake inventor who brings forward a proposition involving the impossible is quite apt to receive a lot of free advertising and exploitation in the newspapers. Further than this, the newspaper reporter and editor are as a rule wholly incompetent to detect the fraud in many of the ingenious schemes which are alleged to involve new discoveries in engineering or science. It lies, therefore, with the technical press to expose these frauds upon the public, if the work is to be done at all.

One of our contemporaries which has shown much enterprise in this work is the journal "Power," of which Mr. Fred R. Low, M. Am. Soc. M. E., is the editor. Some two years ago, "Power" exposed a scheme in Philadelphia, in which it was proposed to use carbonic acid gas to run an engine. Glowing advertisements described the carbonic acid gas which pours out of every chimney as "a vast source of energy." The inventor claimed that if he charged his engine with carbonic acid gas under pressure, it would develop power for many days at a time, without drawing on any outside source of energy. The editor of "Power" attended an alleged demonstration of the engine, and as a result of his examination exposed the scheme as a fraud. A year after this publication some of the officers and stockholders of the company, who had lent a credulous ear to the claims of the inventor, sued him to recover their money. Mr. Low was summoned as a witness in this case, and his testimony was so displeasing to the inventor that he caused Mr. Low to be arrested on a charge of criminal libel, based on the publication a year earlier, and later an indictment was brought against Mr. Low by a Grand Jury.

Such misuse of the machinery of the criminal law adds another item to the long catalog of corrupt acts in the courts and public offices of Pennsylvania which causes every decent resident of that state to blush for shame. Mr. Low was rendering a public service in exposing a fraud. If he passed at any point beyond proper bounds, then the vendor of the fraud had a remedy in a civil suit for damages. But to bring a criminal indictment against a man of Mr. Low's character and standing for utterances on such a subject is the severest possible indictment of the officers of the law who were parties to the securing of the indictment.

Fortunately the case was brought to trial before an upright judge, and the nature of the case was so plain that there was no room for doubt as to where justice lay. As soon as the judge had heard enough evidence to satisfy himself of the nature of the case, he instructed the jury to find a verdict of acquittal for the defendant without leaving their seats.

Our contemporary well says: "This outcome is a victory for technical journalism and for the honest inventor and investor." If the public is to be protected from such fraudulent and foolish enterprises as those which have been frequently exposed in the columns of this journal and in our contemporary "Power," then the right of the technical press to investigate and expose such frauds must be maintained.

The Los Angeles, Cal., "Examiner" of May 7, printed the following:

> Admiral Robley D. Evans has been offered a position at the head of the engineers who will direct the work of improving San Pedro Harbor after the consolidation of Los Angeles with Wilmington and San Pedro. The offer was made by Mayor Alexander, with the understanding that if Admiral Evans consented to make Los Angeles his home, steps would be taken immediately after consolidation for the creation of the position.
>
> When the offer was made it was thought that the wide experience of the famous naval hero from his trips to the harbors of the world would be of immense value in the work of building up the great harbor of the future of Southern California.

It seems to us this item is a rather eloquent commentary upon the ignorance of the public regarding the engineering profession. Apparently, to the editor of the newspaper and to the Mayor of the city, as well as to the citizens of the exceptionally intelligent city of Los Angeles there was nothing absurd in selecting Admiral Evans to be Chief Engineer of an important piece of public work. On the contrary, he seems to have been regarded as an ideal man for the position.

We are not questioning at all Admiral Evans' ability as a naval officer, or his reputation as a national hero; but why should either of these distinctions qualify him to assume the responsibility for a large place of civil engineering work?

Let us turn the proposition the other way round and see how an item like this would read:

> Mr. Isham Randolph, well known to the public and to the engineering profession for his long service as Chief Engineer of the Chicago Drainage Canal as well as for his achievements as a civil engineer in other important works, has been selected to be Admiral of the Atlantic Squadron of the U. S. Navy. It is thought that the wide experience of this famous engineer in dealing with apparatus for the restraint and control of water will be of immense value in the work of controlling vessels which float in this element.

Why not? Is the one item any more absurd than the other? The command of a fleet calls for a long apprenticeship and period of training, it is true, but is not the same thing true of the planning and construction of a harbor?

In fairness to Admiral Evans it should be said that he did not accept the offer of the civil engineering position. He recognized doubtless that it was as absurd to place him in charge of an important civil engineering work as it would have been to make him consulting physician to a hospital or chief legal adviser to the Sugar Trust.

One traveling about the country and observing the condition of freight-car rolling-stock is impressed with the fact that many freight cars are badly in need of painting to protect them from decay. The freight cars of the country represent an enormous amount of money invested; probably a billion dollars would be well inside the mark. It is an investment subject to rapid deterioration—particularly rapid if neglected.

Many of the steel cars in service are rusting so rapidly that their life is going to be much shorter than was anticipated when they were purchased. By proper painting their life would probably be doubled or even quadrupled over what it will be if present neglect continues.

The wooden box-car bodies now in use will cost to replace for lumber probably double what the present cars cost. Not only will it pay to preserve these box cars by proper painting, but it will pay so enormously that the railways cannot afford to neglect them. One sees in many parts of the country wooden houses rapidly going to decay because their owners are too poor or too shiftless to preserve them. But no railway corporation is too poor to preserve its property from destruction. The real cause why freight car painting is neglected is probably mere official inertia. It has long been the custom to paint cars when sent to the shop for general repairs. The cars which have been standing idle on side tracks during the past 18 months have not suffered wear and will not need to be shopped for repairs to running gear for a good while, but they have been exposed to the weather and many of them ought to be hauled to the paint shop and given a proper protective coat before another season of car shortage comes and they cannot be spared.

And better paint ought to be used on freight cars. Not necessarily more expensive paint but better paint. How many railways of the country really purchase their paints with any thorough scientific care to see that they are getting the best and most economical? A few do, and the results show the great advantage of the system; but on too many roads the prejudices of the foreman painter in favor of or against some particular brand, the pull of the paint salesman with the General Superintendent, the friendship of the paint-maker with an influential director—things like these determine the selection of the paint and the freight cars have to make the best—or worst of it.

We are not advocating painting freight cars for appearance. One too-common error is the selection of paint for its looks and not for its durability. What we do urge is that the billion dollar investment in freight cars be preserved, and that the most economical paint for that purpose be selected and applied.

Should a city council or other local governing body ever be given power to regulate the rates charged by a water company or other local public-service corporation? The question is suggested by the seemingly endless litigation at San Francisco over the water rates of the Spring Valley Water Co. Under the constitution of California, rates of local public-service corporations are fixed annually by county boards of supervisors. The city and county of San Francisco being the same, the Board of Supervisors of San Francisco County is identical with the City Council of San Francisco, and thus the local governing body of that city fixes charges for water and gas. The rates as thus fixed have repeatedly been a subject of litigation, and some half-dozen years or so ago the Spring Valley Water Co. entered upon a more vigorous fight than ever before, to have the rates fixed by the supervisors set aside or modified. The fight is still on. Within a few weeks the city attorney has filed a brief in the case, in the form of a volume of 800 pages. According to the San Francisco "Chronicle," this document

> represents a year's painstaking work by Attorney Thomas E. Haven, assisted in the tabulation and arrangement of evidence by Engineer J. H. Dockweiler. Its contention is that the water company has signally failed to prove that the valuation of its property, as made by the supervisors at $25,000,000, is not a fair and reasonable estimate of its worth.

The year occupied by the city in preparing this brief was preceded by two years taken up by the company in similar work for its side of the case, and the company will next present a concluding brief.

We do not propose to go into the merits of the case, regarding which we make no pretension to specific knowledge. We merely desire to make use of the incident to call attention to the desirability of placing rate control in the hands of a state commission chosen to regulate public-service corporations, instead of vesting it in a city council. Theoretically, the local legislative body might be considered perhaps as a disinterested party, standing as arbitrator between

the water consumers and the water company; practically, it is an interested party. But quite aside from this, the regulation of water rates is an administrative or judicial rather than a legislative function, and therefore should not be entrusted to a city council. To appoint a local body especially for this work, unless it be in a very large city where many public-service corporations are to be regulated in other matters as well as rates, would be objectionable in many particulars. Instead, it is preferable to vest the control of rates in a state commission, which through its wider jurisdiction would have so many companies to regulate as to occupy the whole time of a board of men chosen because of fitness for their duties and paid accordingly.

Outside of San Francisco the regulation of rates of local public-service corporations by county supervisors does not have the objection that the regulating body is an interested party. But it is obvious that county supervisors are not likely to be chosen because of their fitness to determine equitable rates for water and gas.

Yearly regulation of the rates of local public-service corporations is so objectionable and unreasonable that we can hardly see how it ever came to be required in California. Of course the San Francisco water-rate litigation is an extreme illustration of the burdensomeness and utter failure of attempts at yearly regulation; but even making allowances for peculiar and unusual conditions in this case, it is still evident that yearly regulation is absurd. Readjustment at intervals of no less than five years, if fewer than ten years, would seem to be sufficient under nearly every condition that can be imagined. But even then, the readjustment might be permissive on the part of the public, instead of mandatory. Is it not far better to name no specific date or time interval for readjustment of rates, but rather to provide means for bringing up the question at any time, on proper petition by the authorized representatives of the city or by a considerable number of citizens? This plan has long been in vogue as regards gas and electric light in Massachusetts, and has been adopted for the past few years in several states which have established public-service commissions.

Typhoid Fever and Water-Supply Statistics for 48 New York Cities.

The vast amount of work that must be done before typhoid fever and water-supply can be properly correlated is strikingly illustrated by the typhoid statistics of 48 cities (Table I. herewith) for the past ten years which are given in the April Bulletin of the New York State Department of Health (Dr. Eugene H. Porter, Commissioner). The figures show, for each city, the average typhoid rate for the ten years 1899 to 1908 and the number of typhoid deaths and the rate for each of the years indicated. The figures are grouped under general character of water-supply, and as a further aid to understanding them the actual source is given for each city, with a statement of the means of purification in use, if any.

The classification of the cities followed in the table raises the question of relationship between the various sources of supply and the highness or lowness of the typhoid rates for the corresponding groups of cities. To simplify comparison, we have taken from the original table the range of typhoid rates in each of the six groups of cities. These we present herewith (Table II.), both for the ten-year period and for the year 1908.

MORTALITY FROM TYPHOID FEVER IN THE CITIES OF NEW YORK STATE FOR THE TEN YEARS 1899-1908, AND FOR THE YEAR 1908.

Character of water-supply.	No. of cities.	Range of typhoid death rates. Av. 10 yrs. 1899-1908.	Year 1908.
Unfiltered river water*	8	23-[illegible]	28-96
Unfiltered lake water*	5	16-[illegible]	11-47
Filtered river water.....	7	22-[illegible]	11-41
Well or spring water.....	7	20-[illegible]	6-78
Streams and reservoirs....	14	15-[illegible]	6-37
Filtered surface water.....	7	10-[illegible]	7-68

*We have transposed these two classes here, as compared with the original (Table I.).

Bearing in mind that all such figures must be

TABLE I.—TYPHOID FEVER MORTALITY FOR THE PAST TEN YEARS IN THE CITIES OF NEW YORK STATE.
(Rate per 100,000 population, with actual figures for 1900 and 1905.)*

City.	Av. rate 10 yrs.	1899.	1900 Total.	1900 Rate.	1901.	1902.	1903.	1904.	1905 Total.	1905 Rate.	1906.	1907.	1908.	Source of water-supply.
Cities using unfiltered lake water:														
Auburn	23.0	23.4	12	39.5	22.9	9.7	25.8	28.8	5	15.9	12.1	6.0	46.6	Owasco Lake.
Buffalo	27.1	25.7	90	25.5	27.4	33.9	36.2	24.4	90	24.0	23.6	29.2	21.2	Lake Erie.
Dunkirk	40.2	17.5	6	51.6	32.4	76.5	29.0	41.3	6	39.3	31.4	71.8	11.1	Lake Erie.
Geneva	29.3	49.2	0	....	46.3	9.0	52.1	42.0	4	32.7	24.0	15.4	22.1	Seneca Lake.
Syracuse	16.2	24.4	31	29.1	18.1	8.9	15.8	14.7	17	14.5	9.2	11.6	15.2	Skaneateles Lake.
Cities using unfiltered river water:														
Cohoes	84.4	88.3	27	113.0	58.4	133.2	91.3	103.6	14	57.9	57.8	78.2	62.0	Mohawk River.
Lockport	48.4	18.1	3	18.0	71.5	35.4	75.7	34.6	9	51.8	67.6	50.1	60.7	Erie Canal. New supply being used recently from the Niagara River at North Tonawanda.
Niagara Falls	132.9	113.0	24	123.3	143.7	148.1	114.0	135.3	49	184.4	154.5	126.0	87.1	Niagara River. Water supplied to one part of the town is partly filtered.
North Tonawanda	30.9	23.1	1	11.0	32.3	10.5	41.1	30.2	4	39.3	19.3	47.2	54.6	Niagara River.
Ogdensburg	54.6	87.8	5	39.5	31.4	62.3	61.7	68.9	7	53.1	67.3	47.1	26.8	Oswegatchie River.
Oswego	49.4	22.6	10	45.0	22.4	17.5	53 5	62.3	19	84.1	58.0	66.0	62.2	Oswego River.
Rome	22.7	26.1	1	6.5	12.2	25.2	18.6	24.5	7	42.3	28.2	17.0	26.4	Mohawk River.
Tonawanda	30.1	13.5	1	13.4	13.3	....	26.0	38.4	2	25.3	50.6	25.0	95.6	Niagara River.
Cities using filtered river water:														
Albany	28.7	87.0	38	40 3	21.1	30.2	19.7	18.5	19	19.3	20.3	20.0	10.9	Hudson River. Filtered since Sept., 1899; also some unfiltered surface water. (Slow sand filtration.)
Binghamton	22.2	25.6	17	42.8	52.4	27.1	9.7	9.6	5	12.0	9.1	81.2	15.2	Susquehanna River. Filtered since June, 1902. (Mechanical filtration.)
Elmira	41.0	33.6	17	47.6	25.4	39.7	80.0	51.6	10	28.8	44.7	28.0	30.7	Chemung River and storage reservoir on Hoffman Creek; all water is filtered since 1896. (Mechanical filters.)
Poughkeepsie	46.5	25.1	11	45.7	41.1	20.3	44.2	59.7	11	43.3	39.4	112.0	34.5	Hudson River. Filtered. Plant improved fall of 1907. (Slow sand filter.)
Rensselaer	61.9	107.3	7	93.7	61.6	91.2	31.8	89.4	4	37.3	18.6	58.3	30.0	Hudson River. Filtered since 1902. (Mechanical sand strainer.)
Watertown	71.9	85.7	22	101.4	35.6	64.7	71.0	211.0	6	23.6	50.0	37.1	39.0	Black River. Filtered since October, 1904. (Mechanical filter.)
Watervliet	57.5	105.7	11	77.0	55.6	62.3	55.2	61.8	7	47.9	47.7	20.4	41.1	Mohawk River. Filtered. (Sand strainer.)
Cities using well or spring water:														
Corning	46.4	27.7	6	54.2	43.2	24.9	48.0	46.1	4	30.0	43.1	69.0	78.2	Springs.
Cortland	29.2	55.8	3	33.2	116.2	10.1	....	9.2	3	26.6	8.7	24.6	7.9	Springs.
Fulton	33.2	25.0	0	....	24.0	11.8	93.2	34.8	2	22.6	56.5	22.0	42.5	Wells and springs.
Ithaca	51.7	7.8	6	45.6	44.6	7.3	357.0	27.9	2	13.7	6.8	....	6.4	Six Mile Creek. Unfiltered until epidemic in 1903. Since then a filter has been used or water has been taken from deep wells and springs.
Olean	19 5	21.6	1	10.5	20.8	30.7	30.3	20.0	0	....	20.0	19.1	22.1	Driven wells.
Jamestown	28.9	40.5	9	39.3	25.5	4.1	24.1	62.7	6	23.0	33.8	18.2	17.5	Artesian wells.
Schenectady	31.6	8.3	14	44.2	40.5	26.0	33.5	22.6	5	8.6	17.8	8.7	10.9	Large wells. Mohawk River discontinued 1903.
Cities using water from streams & reservoirs:														
Amsterdam	19.4	19.8	3	14.3	23.2	18.1	44.0	17.1	4	16.7	24.8	15.9	0	Creeks with large reservoirs.
Glens Falls	37.6	24.6	6	47.6	61.4	14.9	28.9	49.2	3	20.4	46.5	45.3	36.9	Surface streams and storage reservoir.
Gloversville	20.0	16.7	9	49.0	5.4	43.3	10.8	5.4	4	21.4	5.3	5.3	37.3	Streams and storage reservoirs.
Johnstown	19.1	20.2	7	69.1	....	20.0	30.1	....	1	10.2	20.4	....	21.1	Springs and streams.
Newburgh	39.6	48.4	11	44.1	23.7	47.0	34.7	42.0	10	37.1	41.3	41.0	36.4	Small streams and storage reservoir.
New Rochelle	21.1	7.1	1	6.8	38.0	29.3	22.0	15.5	4	19.5	23.2	22.0	28.0	Surface streams and storage reservoirs. Small quantity from wells at times.
Plattsburg	21.0	24.1	2	23.7	34.1	11.0	21.1	....	4	39.2	28.7	27.6	0	Surface streams and reservoirs.
Rochester	14.9	20.0	30	18.4	19.2	11.2	12.1	15.2	19	10.5	16.2	14.3	11.6	Hemlock lake and tributaries.
Troy	49.2	65.1	76	101.2	55.7	48.8	32.8	44.4	36	46.8	36.2	25.8	34.9	Small lakes and streams. Partial use of Hudson River discontinued May, 1906.
Utica	17.3	16.3	8	14 1	15.6	20.3	16.6	17.8	6	9.5	27.6	15.2	20.1	Small surface streams.
Port Jervis	42.7	10.6	3	31.9	31.8	52.5	73.1	72.6	7	72.2	31.0	51.0	0	Surface ponds and streams.
New York (Greater)	17.4	16.3	718	20.8	20.4	20.8	16.8	16.9	635	15.8	15.5	17.4	12.8	See foot note. (†)
Little Falls	36.4	29.3	13	125.2	28.5	37.5	27.7	36.4	0	....	44.7	8.8	25.9	Surface water from two different streams. (Filter abandoned.)
Oneida	17.2	26.5	1	13.3	25.9	38.0	....	36.3	0	....	11.8	....	19.8	Springs.
Cities using filtered surface water:														
Hornell	28.8	76.1	3	25.1	32.8	32.1	55.0	7.7	4	30 2	7.5	7.5	14.1	Surface water. Filtered since 1899. (Mechanical strainer filter.)
Hudson	59.2	62.8	0	94.4	41.3	81.3	30.0	167.7	5	48.5	38.0	9.4	18.1	Hudson River. Filtered prior to February, 1905. Purer small streams filtered since then. (Slow sand filter.)
Kingston	19.4	28.9	2	8 1	12.1	16.0	19.9	11.8	8	31.3	15.6	27.0	22.9	Surface streams and Cooper Lake, filtered. (Mech. filter.)
Middletown	24.5	21.0	2	13.7	13.8	55.1	13.8	6.9	6	41.3	18.8	18.8	42.1	Surface water filtered. (Mechanical pressure filter.)
Mount Vernon	14.6	5.0	1	4.9	13.6	8.8	8.5	20.6	5	20.0	19.4	37.7	7.1	Surface water filtered. (Mech. filter & sand strainer.)
Oneonta	37.9	28.7	2	27.9	13.6	66.5	26.0	50.8	2	24.8	48.6	23.8	68.2	Surface water filtered. (Mechanical pressure filters.)
Yonkers	9.9	10.8	2	4.1	15.9	9.3	14.2	15.2	1	1.6	6.2	11.9	9.6	Surface streams and storage reservoirs unfiltered; tube wells and Sawmill River, which is filtered. (Slow sand filtration.)

*The original table, in the March Bulletin of the N. Y. State Department of Health gives the number of typhoid deaths for each year. To save space and confusion we give the deaths for 1900 and 1905, only.

†The sources of supply for the different boroughs of Greater New York are as follows: Boroughs of Manhattan and the Bronx obtain their water from streams, lakes, ponds and reservoirs on the Croton, Bronx and Byram watersheds. Borough of Brooklyn, about 60% of the water is underground water or is filtered through artificial filters; the remainder is surface water from streams and storage reservoirs. Borough of Queens water supply is underground water from driven wells. Borough of Richmond obtains underground water from wells.

considered broadly, the range of typhoid rates by groups falls into about the order that would be expected, with the exception noted below. That is, unfiltered river water shows a notably higher typhoid rate than any other general source of supply, and unfiltered lake water comes next. The surprising feature of the summary is that the seven cities having filtered river water come third in the list, with a range of 22 to 72 deaths per 100,000 for the ten years and 11 to 41 for the year 1908. These figures are higher than those for cities supplied with unfiltered water from either wells and springs or streams and reservoirs (presumably impounding reservoirs or small streams). It should be explained, however, that most of the cities now using filtered river water used unfiltered water from the same sources during the earlier part of the period. The changes to filtered water are reflected in the figures for 1908, which are about half the range for the ten-year period; but it should be remembered that the one-year figures show every extreme that may have occurred, while the column of ten-year figures has had both extremes eliminated by the process of averaging.

That the supplies classed as "streams and reservoirs," though unfiltered, should stand next to the lowest in typhoid death rates seems all the more remarkable when we consider that there are 14 cities in this group, against eight in the unfiltered river-water group, and that among the 14 are Greater New York, Rochester and Troy. A considerable part of the New York supply is either from wells or is filtered, and much of the unfiltered surface water has long periods of storage.

Storage or lack of storage is the key that would unlock some of the mysteries of the summaries. This characteristic of the various supplies is mentioned in the table, but as a rule no idea of the storage period is given. While it would be difficult to secure accurate figures as to the length of storage, yet we presume that approximations sufficiently close to warrant broad generalizations could be obtained for each city. We hope the State Department of Health will yet be provided with sufficient money to warrant going into the storage phase of this subject—and many other neglected phases as well.

The relatively small size of the cities included in the last three groups of our small table should be taken into account in considering the significance of the typhoid rates in those groups. This does not matter so much for the ranges drawn from the ten-year averages as for the ranges for the single year 1898, and particularly for the zero rates for that year under "streams and reservoirs." Unless a very high typhoid rate prevails, then the smaller the city the greater the chance that occasionally a year will pass with no deaths whatever.

It so happens that of the 14 cities classed as taking water from streams and reservoirs three, each small, reported not a single typhoid death in 1908. These three, with their average rate per 100,000 for the ten years, were as follows; Amsterdam, 19.4; Plattsburg, 21.0; Port Jervis, 42.7. The Port Jervis average for ten years is higher than the highest rate for 1908 of any of the 14 cities in this class.

While certain broad relations between the kinds of water-supply and the rates from typhoid fever seem to be beyond question, yet it is evident that these relations are not so clearly defined as one might expect and that they are far less satisfactory than one would wish, especially if our summary is studied in the light of the many variations shown by the detailed tables. So far as the ten-year averages are concerned, this lack of demarcation is partly due to changes in the sources of water-supply of some of the cities during the period. But this is not an adequate explanation. Let us look farther.

Thus far we have ignored, as was the case with our source of information, two very important factors in the study of typhoid death rates: (1) the reliability of the statistics and (2) all other factors than the public water-supply which influence typhoid. All questions relating to the accuracy of the figures we will dismiss, with the remark that an omission of even one typhoid death in the smaller cities has a striking effect on the rate per 100,000, while errors in population estimates may affect materially the rates of a considerable number of cities.

As to other factors than water-supply, it is now known that these are many and vital in the causation of typhoid fever. And yet no State in the Union seems to have advanced far enough in public sanitation and the recording and interpreting of vital statistics to be able to make a study of typhoid fever throughout the cities of the State that would extend beyond an incomplete presentation of the relation of public water-supplies to the prevalence of the disease.

This would involve explorations of a number of other fields than water-supply in the endeavor to explain the many and marked variations in typhoid death rates, not only as between different cities, but also from year to year in the same city. Of these many fields awaiting exploration, two which are of fundamental importance are (1) the general efficiency of local boards of health, with special relation to their control of typhoid cases; and (2) the worth or worthlessness of local vital statistics, including estimates of population. Next in importance to the character of the work of local health boards and the reliability of their vital statistics come the measures in force to effect the sanitary control of the milk supply and after this comes the control of infection by flies. In many cities flies are probably a more potent factor in the spread of typhoid than is the milk supply, but fly control has received so little adequate attention, as compared with milk control, that the latter may, for the present, be put first.

Secondary or contact cases of typhoid deserve the closest study in attempting to explain why typhoid rates in a given city or group of cities should be high or low, but measures to prevent contact cases, such as disinfection of excreta, bed linen, etc., screening windows in fly time, and some degree of isolation of patients and their attendants, are included in the general field of character of local health-board work, already mentioned. Likewise prompt reporting of typhoid cases by attending physicians comes under health-board work.

It should be borne in mind that we are now discussing methods of controlling the spread of typhoid fever wholly from the viewpoint of their relation to the interpretation of typhoid statistics; and that our object in doing this is to emphasize the importance of broader surveys of typhoid causes than have been made heretofore.

The time has come to quit placing the whole responsibility for typhoid fever on public water-supplies. This does not mean that we should stop trying to trace the relation between water-supply and typhoid. Instead of stopping that valuable work we should extend it and make it far more trustworthy than it is to-day. We should take into account storage as well as filtration as a means of lessening the dangers of typhoid infection; also such influences as density of population on drainage areas, and amount of direct sewage pollution of the water-supply in relation to both volume of water and nearness to intake.

Until the time comes when our water-supply and typhoid statistics can be bettered in the ways suggested, and our typhoid statistics can be interpreted by the aid of data from other fields than that of water-supply, we shall, of course, welcome carefully prepared typhoid death totals and rates, grouped according to the kinds of water-supply, even though they go no further. But we ought not to allow our minds to be longer befogged by the seeming inconsistencies of such classified tabulations, nor should we continue to place the whole or nearly the whole blame for high typhoid rates or give the whole credit for low rates to the character of our public water-supplies.

In dispelling the water-supply and typhoid fallacies of the past who should take the lead if not our more progressive State boards and departments of health? Until the public gets the new point of view ought not all tables like the one on which we have been commenting be accompanied by explanatory notes or text to the effect that doubtless many of the wide variations in typhoid statistics of different cities and years were due to some one of many causes not at all related to the public water-supply? What State will take the lead in this, and in the still more important work of attempting to exhibit all the causes that make for both high and low typhoid rates?

LETTERS TO THE EDITOR.

Strength of Cement Briquettes When Stored in Air.

Sir: The writer wishes to bring to the attention of the engineering public some rather interesting phenomena which present themselves when briquettes, after being taken from the water, are allowed to dry out somewhat before testing. Since all specifications so explicitly state that briquettes shall be tested immediately on being taken from the water, the writer has, for some time, been rather curious to find out what effect drying out would have on them. With this idea in view a set of tests has been made covering neat, 1:1, 1:2 and 1:3 specimens, the latter three being tested at the ages of 7 and 28 days and the neat specimens at the age of 1, 7 and 28 days. The 1-day neat specimens really have no place in this series since they were kept in air for the whole 24 hours, but are put in to give an idea as to the character of the cement. With the exception of the fact that the briquettes were allowed to dry out for

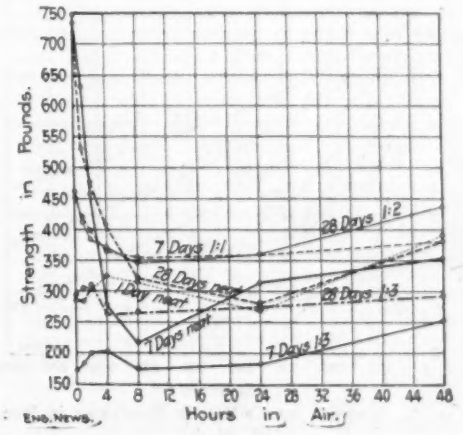

Diagram Showing Strength of Cement Briquettes Setting in Air.

certain lengths of time in air at 70° F., the standard procedure was followed throughout the work.

The sand used was a rather impure glacial drift material which weighed 110 lbs. per cu. ft., having a percentage of voids of 32.7. In size it ranged fairly uniformly from material just passing a No. 10 sieve to that just passing the No. 100 sieve. The cement, which was of standard brand, passed all the standard tests satisfactorily. For the neat cement 22% of water gave the normal consistency and for the 1:1, 1:2 and 1:3 mixtures 16.7%, 15.9% and 15.1% of water, respectively, was used.

TABLE SHOWING STRENGTH OF CEMENT BRIQUETTES OUT OF WATER.

		Hours Out of Water.						
Age.		0	1	2	4	8	24	48
in water.	Mix.	Lbs. per sq. in.						
1 Day	Neat	293	305	304	324	315	268	291
7 Day	Neat	734	631	457	278	217	313	352
28 Day	Neat	746	630	476	408	318	282	382
7 Day	1:1	451	421	398	365	355	359	382
28 Day	1:1	624	570	493	...	...	...	...
7 Day	1:2	280	270	267	...	...	...	...
28 Day	1:2	460	413	385	370	346	360	437
7 Day	1:3	172	183	200	203	174	183	254
28 Day	1:3	284	283	300	263	266	275	293

In the results, which are given herewith both in tabular form and diagrammatically, each value represents the average of 15 specimens, and the age, as given, is that at which the briquettes were taken from the water. The general phenomenon is that of a loss of strength for some hours, followed by a gradual recovery, the decrease being proportional to the richness of the mixture.

The 7-day neat drops from 734 to 217 lbs. per sq. in. in 8 hours, the 28-day neat drops from 746 to 282 in 24 hours, the 7-day 1:1 from 451 to 355 in 8 hours, and the 28-day 1:2 from 460 to 346 in the same amount of time. Owing to the incompleteness of the series the loss of strength of the 7-day 1:2 and the 28-day 1:1 cannot be told, but it is evident that both lose materially. The 1:3 mixtures seem to gain a little and then lose a little, but the change is so slight that no definite conclusions may be drawn. The loss in strength appears to go on at a fairly uniform rate for about eight hours, after which little change takes place up to 24 hours, but from this

point a gradual recovery of strength begins to take place.

Any attempt on the part of the writer to explain the cause of this action is only the roughest kind of guesswork, but it seems possible that we have here an action somewhat analogous to that of steel when subjected to various degrees of heat, namely a changing of the crystalline structure of the material, and during this period of transition the cohesion of the cement becomes very small while its power of adhering to the sand is not appreciably affected, thus explaining the very great loss in the case of the neat and the very slight loss in the case of the 1:3 mixture. The writer would like to see this matter discussed by some of the authorities on the subject, for although perhaps not a subject of great practical importance, it is certainly an interesting one.

Yours respectfully,

R. P. Davis.

Ithaca, N. Y., May 8, 1909.

Earthwork Calculations for Side Hill Work.

Sir: In connection with our work of making a survey and estimate for the double-tracking and relocation of the Lehigh & Hudson River Ry., I have worked out the following method for calculating the correction of level section quantities for side hill work.

In the accompanying figure $S\,S'\,B'\,B$ represents any cross-section in a cut and $L\,L'\,B'\,B$ represents the level

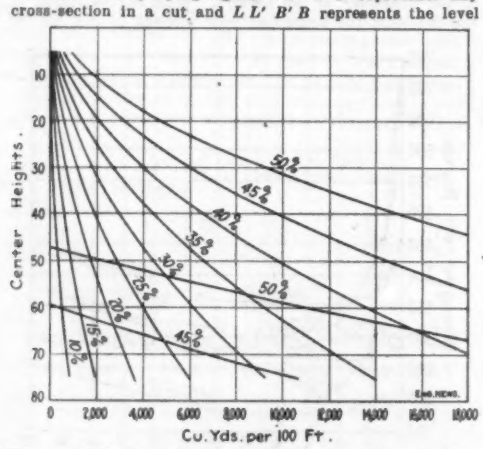

Fig. 1. Diagram for Earthwork Quantities in Side Hill Work.

18-ft. Roadbed, 1½ to 1 Slopes.
Correct within 10% for 14 — 22 ft. roadbeds.

Formula $\frac{100}{27} \times \frac{P^2 S}{10{,}000 - P^2 S^2} (\frac{1}{2} B + S H)^2$

P = Grade side hill in feet per 100 ft.
S = Hor. dist. per 1 ft. rise in side slope of X-Section.
B = Base of roadbed in feet.
H = Center height of X-Section in feet.

section having the same center height; h = center height of the section; b = the base; s = the horizontal distance for 1 ft. rise in side slopes; p = the per cent. of the side hill grade.

The level section correction is the difference in the areas of the triangles $S\,L\,O$ and $S'\,L'\,O$, and a general expression for this difference will therefore be also a general expression for the above correction.

The length of $O\,L$ and of $O\,L'$ is $\frac{b}{2} + s\,h$.

Draw two lines parallel to $L\,L'$ the one 1 ft. above and the other 1 ft. below it, and also draw the perpendiculars m, n, m' and n',

$$O\,m = \frac{100}{P} \qquad L\,n = s$$

$O\,m - L\,n = \frac{100}{P} - s$, which is the amount by which the base of the triangle $S\,O\,L$ becomes shortened when its altitude is reduced by 1 ft.

The altitude = the base divided by the shortening of base per ft. reduction in altitude

$$= \frac{b/2 + s\,h}{100/P - s}$$

Then the area of the triangle

$$S\,O\,L = \frac{1}{2}\left(\frac{b/2 + s\,h}{100/P + s}\right) \times (b/2 + s\,h)$$

Similarly the area of the triangle

$$S'\,O\,L' = \frac{1}{2}\left(\frac{b/2 + s\,h}{100/P - s}\right) \times (b/2 + s\,h)$$

The difference in the areas of these two triangles is

$$\frac{1}{2}\,\frac{(b/2 + s\,h)^2}{100/P - s} - \frac{1}{2}\,\frac{(b/2 + s\,h)^2}{100/P + s}$$

which can be reduced to

$$\frac{P^2 s}{10000 - P^2 s^2} (b/2 + s\,h)^2$$

This expression multiplied by $\frac{100}{27}$ is the general expression for the correction of level section quantities in cubic yards per 100 ft. for side hill slopes. Since inverting the figure does not change the relation of any of its parts the same formula holds true for fills also. By inspection it can be seen that these quantities will always be additive.

The expression $\frac{100}{27} \times \frac{P^2 s}{10{,}000 - p^2 s^2}$ is constant for any

center height and the expression $\frac{b}{2} + s\,h$ is constant for any grade of side hill. The accompanying table has been worked out with this in view. The first two columns are filled out. Then the quantity for each remaining space is found by multiplying together the corresponding values of the columns mentioned above. Much tedious work will probably be saved by using this form.

The diagram plotted from this table (Fig. 2) is self-explanatory; values for intermediate slopes can be found by interpolation. When the roadbed is 18 ft. wide and the side hill grade is 50% the formula does not hold true for a cut or fill under 4.5 ft., as the side hill grade under these conditions will strike the subgrade inside of the slope. So far as I am able to find, a diagram of this sort has never been worked out before, and it can be made a valuable refinement in paper location work.

One who has never stopped to consider the question might imagine that since the slopes are likely to run about as often one way as the other, the errors will average up in the long run. But this is not the case, as a moment's consideration will show that the errors are always accumulative, no matter which way the slope runs or whether the cross-section is in cut or in fill.

In our paper location work we use a regular profile quantity scale, arranged as shown in Fig. 3, and read the level section quantities directly from the profile. These quantities are noted in their proper column in the standard form. Next a man runs over the trial line and calls off all transverse slopes over 10%; the grades of the slopes are found by counting the number of contours in 50 or 100 ft. The correction column is then filled out by reading from the diagram the correction corresponding to the side hill slope and the center height or level section quantity at each station. In the total quantity column only the sum of all of the level section plus the sum of all of the correction quantities in each cut or fill are noted.

When the work is carried on in this way it will save time in reading the level section correction diagram if each line representing some foot of center height is marked with the level section quantity corresponding to that height.

Yours respectfully,

Robert S. Beard,

Asst.-Engr., Lehigh & Hudson River Ry.

Warwick, N. Y., March 22, 1909.

Table of corrections of Level Section quantities for side hill slopes

	$\frac{P^2 s}{10000 - P^2 s^2}$	.056634	.131668	.244200	.404040	.626959	.935507	1.366886	2.064[illegible]	3.174603
					Side hill slopes					
$(\frac{B}{2}+SH)^2$	Center Height	10%	15%	20%	25%	30%	35%	40%	48%	50%
27225	5	153	358	665	1100	1707	2558	3781	[illegible]	8643
57600	10	430	758	1406	2327	3611	5411	8000	[illegible]	18286
99225	15	564	1308	2423	4009	6221	9322	13781	[illegible]	31500
152100	20	864	2003	3714	6145	9536	14290	21125	[illegible]	48286
216225	25	1230	2847	5280	8736	13556	20315	30031	[illegible]	68643
291600	30	1657	3839	7121	11873	18282	27396	40500	[illegible]	92571
378225	35	2150	4980	9236	15282	23713	35535	52531	[illegible]	120071
476100	40	2706	6269	11626	19236	29840	44730	66125	[illegible]	151143
585225	45	3326	7705	14291	23645	36681	54982	81281	[illegible]	185786
705600	50	4010	9290	17231	28509	44238	66281	98000	[illegible]	224000
837225	55	4758	11023	20445	33827	52490	78658	116281	[illegible]	265786
980100	60	5570	12904	23934	39631	61448	92081	136125	[illegible]	311143
1134225	65	6446	14933	27698	45827	71111	106561	157531	[illegible]	360071
1299600	70	7386	17111	31856	52509	81480	122038	180500	[illegible]	412571
1476225	75	8390	19437	36049	59645	92553	138692	205031	[illegible]	468643

Earthwork

Sta.	CUT Level sec. Quantities	CUT Transverse Slope	CUT Slope Correction	CUT Total Cu.Yds.	FILL Level Sec. Quantities	FILL Transverse Slope	FILL Slope Correction	FILL Total Cu.Yds.
119	8250	42%	5600					
120				13850	3000	15	150	3150

FIG. 2. DIAGRAM OF CORRECTIONS OF LEVEL-SECTION QUANTITIES FOR SIDE HILL WORK (CU. YDS. PER 100 FT.); LEHIGH & HUDSON RIVER RY.

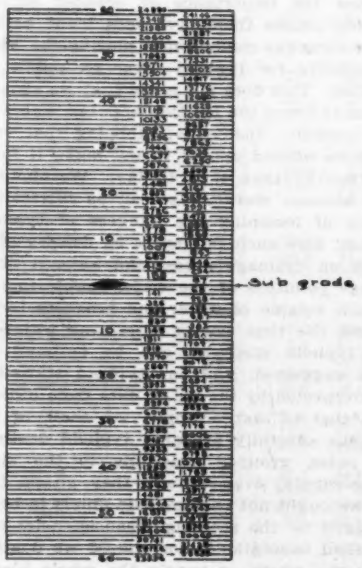

Fig. 3. Quantity Scale for Preliminary Estimates of Earthwork.

(Note.—To find the earthwork yardage at any station, place the right-hand end of the zero line on the grade line at that station, and read the yardage opposite the line which meets the profile.)

End Latches Recommended for Incline Railways.

Sir: Again we read of an incline cable railway accident (at Pittsburg on April 6) resulting from a failure to stop the engine when the car struck the buffers at the top landing.

Doubtless there are many adequate safety-devices now in use for the prevention of accidents on cable inclines, of which the writer is not informed, and probably the idea here submitted is not a new one. If, however, this simple device can be utilized to save the lives of its patrons in the future, the railroad world is welcome to it.

[A sketch which accompanied the letter shows a double latch, consisting of two barbed latch-bars fixed to the abutment, the bars being pressed toward each other by a spring, and a catch shaped like an arrowhead attached to the front of the car. As the car reaches the end of its trip, the head of the catch enters between the latch-bars and forces them apart, until they spring back and engage the rear faces of the head of the catch. A toggle or other device, operated by a hand lever, forces the latch-bars apart when the car is to start on its return trip.—Ed.]

This device does not provide for breaking of the cable while the car is in transit, but the most serious accidents on passenger inclines have been caused, as far as the writer is informed, by over-winding.

Very truly yours,

A. L. Dabney.

Clarksdale, Miss., May 12, 1909.

Notes and Queries.

The Missouri River Bridges listed by Mr. J. Y. Oleson in our issue of April 29, 1909, p. 460, include all the bridges that have had authority from Congress. There are six other bridges in Montana, of small size. They include two road bridges at Craig, Cascade and Great Falls, and a railway bridge below Great Falls. The total then becomes 21 bridges over the Missouri.

In our issue of April 22 we published the enquiry of a correspondent as to the use of the term "cord" as a measurement for stone. Another correspondent, in Michigan, now writes that the cord, of 128 cu. ft., has been, for many years, the common unit of measurement for stone on Lake Michigan, both for use in harbor work by the Government and for use by private parties. At present it is giving way in some cases to measurement by the ton of 2,000 lbs.

In our issue of May 6, p. 499, an explanation was given by Capt. William V. Judson, of the reasons why freight traffic in the United States does not seek the waterways as it does in Europe. A correspondent calls our attention to other reasons for this, and particularly the arbitrary fixing of railway rates in Germany on a mileage basis. This raises the rail rate on traffic hauled long distances to such a high figure that it naturally turns to the waterways. With American railways under private management, special rates are made where water competition exists, and the shipper gets the advantage of the very low cost which is possible where freight is moved over long distances.

Apropos of the recent discussion respecting engineers, their duties and their compensation, a correspondent sends a letter from which we take the following extracts:

In an emergency, I sent into the field and called one of my men to take a party out at 8 p. m., notifying him about 3 in the afternoon. He was to have been married at 8, so he got married at 7, took the party out at 8, was gone six weeks and told me about it after he got back. It is unnecessary to say he has made good.

Never having had any school advantages except three terms at a school that nowadays would be inferior to the average high school, perhaps I am unduly prejudiced against a college course, thinking that the five years spent might be better employed. What's the use, when I can hire men for $50 per month who can calculate an eclipse and handle the integral calculus, and I am just mean enough to do it!

Fundamental Principles of Sewage Purification on Land.

(*Continued from Engineering News, May 6, 1909, p. 490.*)

By RUDOLPH HERING,* M. Am. Soc. C. E.

Distribution.

Keeping in mind the necessity of giving sewage the greatest practicable surface exposure to bacterial action in beds of sand or stone, we must endeavor to secure as nearly as possible a uniform distribution over such a bed and thereby the maximum efficiency of the bed. Should we have larger quantities percolating more rapidly at some parts and smaller quantities at others, we would naturally get uneven results in the oxidation. Some sewage would be insufficiently oxidized and other sewage might be better oxidized than necessary for the particular case, both results being unsatisfactory, the latter by unnecessarily increasing the cost.

An ideal distribution would be one in which the sewage is placed uniformly upon the bed, as from a fine rain. In practice, distribution has been controlled by considerations of economy, and the following methods are now generally used.

In sand filters, the rate of percolation is so slow, due to the friction through the fine-grained material, that it is practicable to flood the entire bed and let the sewage soak into the sand with a fair uniformity per square foot. This may be accomplished by broad flooding or by trench flooding. Both methods are used, but the latter generally gives a better control and has some advantage in crop irrigation. In sand filters, capillarity draws water in a lateral direction.

In stone filters, the rate of percolation is faster; the larger the stone the more rapid it is. The rate of percolation, within limits, increases also with the rate of sewage application. Capillarity does not draw the water laterally to any extent. Therefore, for stone filters an application by flooding is impossible.

SAND-COVER DISTRIBUTION.—Two methods of applying sewage to beds are practicable and have been adopted. One is the placing of a sand layer, about 6 ins. in thickness, on top of the stone bed, with the necessary intermediate layers. This sand cover is strongly advocated by Dunbar and carried out on a large scale at Harzburg, Germany, where I saw its effect after one year's use, and found that it was quite satisfactory. Distribution upon beds covered by sand layers is accomplished in the same way as on any sand filter. Below the sand cover, the sewage is so evenly distributed by gravity and capillarity, that it afterwards percolates through all parts of the stone bed at practically uniform rates. Ample aeration of the stone bed under this cover is imperative. Dunbar has placed vertical pipes in the bed to connect the drains with the atmosphere. I believe that a slight excess of pressure brought about by wind, as mentioned above, might still further improve the oxidation.

Another material advantage of the sand cover is that it serves as a screen for holding back the suspended matter, thereby reducing the work required in the preparatory treatment, and furnishing the oxidizing filter with a clarified liquid. The sand naturally needs raking and periodical replacement, as is generally necessary for the regular intermittent sand filters.

Most of the suspended matter that leaves a sprinkling bed consists of what was brought upon it and perhaps has been slightly or even greatly altered within it. Dunbar, therefore, rightly concludes that its removal from the sewage should be effected, so far as practicable, before it reaches the bacteria for oxidation, and that for this reason the sand cover is specially efficient.

Another advantage of the sand cover is that it does not interfere with distribution in cold weather as much as do sprinkling beds, herein also resembling the sand filters.

The pooling on sand covers, whether these are but a shallow layer or constitute the whole bed, can be prevented only by the usual raking and removal of sludge, or by the replacement, after years of service, of the upper few inches of the material.

Perhaps the most serious drawback of the sand cover is the friction of the liquid when flowing through its fine material, and the consequent restriction in the rate of application to smaller quantities per acre, than could be treated by the sprinkling method, which is the second method presently to be mentioned. Yet this lower rate could be objectionable only when it produced an effluent of unnecessarily high grade.

The annual cost estimate for a desired degree of purity will decide the question as to whether such a sand cover or other methods of distribution will be preferable, taking into account local conditions of temperature and aeration.

DISTRIBUTION BY SPRINKLERS.—The sprinkling method of distribution is generally sufficient when merely a non-putrescent effluent is required, although by a sufficient increase of bacterial surface, any desired increase of purity can be obtained by it. As the air supply is freer through stone beds the oxidation is facilitated, the time of purification is shortened and the economy therefore increased.

As above stated, the distribution should be as uniform as possible. This condition may be obtained by fixed or movable sprinklers. Of the two sprinkling filters that were first introduced (about the same time) the one in Salford employed the fixed and the one in Accrington the movable sprinkler. There appears at present to be no unanimity of opinion as to which gives the better results, although for European conditions the movable kind seems to be preferred and it is much more frequently used.

No application has yet been made of the somewhat different method of sprinkling from fixed orifices, now used extensively in Europe for deferrization of water, where water drops from perforated pipes like rain uniformly over a sand bed so as to oxidize the dissolved iron which it contains.

Practical difficulties at once appear if sewage is applied in this manner, on account of the stoppage of the orifices with slimy matter and the necessity of frequent cleaning. In Germany, where such deferrization works are numerous, trial works, based on similar plans, for well prepared sewage have been suggested, but I believe not yet tried.

As between the fixed spraying nozzle and the movable distributors of the English type, I find that most of the experience justifies the following conclusions regarding the advantages and disadvantages of each.

The chief advantage of the fixed nozzle over the movable distributor is in economy of installation and operation. There is but the simple nozzle to take care of in place of the moving apparatus, which must be strong enough to support itself and resist the effect of wind. Owing to the greater simplicity of the nozzle there is much less to get out of order. The nozzle is a contrivance that stays where it is put, while the revolving arms or travelers need special attention, due to their movable parts. During high winds they are sometimes put out of service when the fixed jet is not disturbed.

In cold weather, such as we have in the northern United States, the fixed nozzle is again preferable. Mr. Watson states that at the Birmingham works only the very fine and more distant particles of spray freeze upon the bed. Near the jet, where the volume of water is greater, the bed remains open and the distribution continues beneath the ice. As the percolation is vertical and the temperature lower there must, during such times, be a considerable reduction in the oxidizing capacity of the bed.

No special power is necessary to operate a fixed sprinkler. The height and distance to which the drops are carried depend upon the pressure head, which is much greater than that required for the moving distributors. This head permits the use of a special chamber or dosing tank, which is so designed that when the sewage flows upon the bed, its head oscillates and thus effects a better distribution over the area. Such chambers are used, also, to effect an intermittency in the distribution, as mentioned below.

Another advantage of the fixed sprinkler is that the spray necessarily breaks up the liquid into finer particles than any other method of distribution, and therefore spreads the drops more uniformly over a larger part of the upper layer of stone. As the percolation is again vertical the bed is therefore more efficiently utilized. As the smaller drops expose a greater surface to the air they also absorb more oxygen.

Finally, there may be a slight advantage of the fixed sprinkler in the possibility of using it for irregularly-shaped beds, while the moving sprinkler requires either circular or rectangular beds.

The fixed nozzle usually wets a circular field and therefore leaves a large area between the circles unused. Nozzles designed to wet a square bed, and thus to utilize the entire stone surface, have been tried. But practical difficulties in operation have caused them to be very little used in Europe.

A more common and better arrangement is to stagger the nozzles, so that the circles may slightly overlap. Then we are practically getting a hexagonal distributing field and are thus also utilizing practically the entire area of the bed. The square distributing nozzle, by a slight turn, puts the square out of line, while a hexagonal, or rather a staggered circular distributing nozzle, is always in adjustment.

The chief disadvantage of the fixed over the movable distributor lies in the relative lack of uniformity of distribution and therefore in failing to utilize the stone beds to their full capacity. No nozzle can be devised to effect as uniform a distribution as either a revolving or rectilinear distributor, with definite points from which the liquid drops. Mr. Watson admits that his fixed jets at the sewage works of Birmingham, England, show volumes varying from 30% above to 30% below the normal. Granting that movable sprinklers give a uniformity within 5% of the normal, the difference of effective area of stone bed between the two is still considerably in favor of the latter and correspondingly reduces its cost. Special dosing tanks, in which

*Hydraulic and Sanitary Engineer, 170 Broadway, New York City.

a variable head can be produced, materially reduce this depreciated area. Nevertheless, it must be admitted that the stone area will be more efficiently utilized by moving than by fixed sprinklers.

Without a dosing tank, the fixed sprinkler has the disadvantage over the movable one, that it cannot well adjust itself to varying rates of flow. Where sufficient head is not available for throwing the spray to the desired distance, the fixed distributor is again at a disadvantage, because it must have a greater head than the movable one.

Nevertheless, it is generally necessary to move the revolving and traveling distributors by a small power, so as to produce positive motion at all times, and particularly to counteract wind effects, or temporarily reduced flows at night. Insufficient liquid to overcome the friction produces stoppage and the liquid all flows out at one position and defeats the object of distribution.

Another objectionable feature of the nozzle, although it differs in this respect but little from the moving distributor, is its liability to give an irregular spray and perhaps come to a complete stop. The irregular spray is caused by material collecting on the point of the cone of the nozzle, on the knife edges designed to cut the spray, where they exist, and by fungus growth on rough surfaces, and in enlarged parts under the aperture of the nozzle, where the accumulation is sometimes sufficiently large to stop the flow. At Birmingham, England, stoppage is caused more by accumulation of grease than of growths.

Some of the defects of both kinds of sprinklers can be overcome by housing them for protection against wind and weather. It is then necessary to ascertain whether the increased efficiency pays for the cost of the housing, which appears unquestionable in the colder sections of our country. Other defects may be minimized by a better preparation of sewage to reduce the amount of fats, and by better aeration of the same to reduce the amount of growths.

The preference between the various practical methods of distribution will generally rest upon the annual cost under given conditions, which are chiefly the winter climate, the available head or power, and the probable care which will be given to operating the works.

The sand-cover distributor is likely to be most advantageous where a fairly high degree of purity is required for the effluent.

A fixed sprinkler, when working under a constant head, is generally the least effective among all sprinklers. Operated with dosing device it is, under many conditions, the most economical means of rendering liquid sewage non-putrescent. The movable sprinkler is in close competition for economy and efficiency. Per square foot of bed surface of equal depth and size of stone it usually turns out a better effluent. The best of the movable sprinklers are those of the Fiddian and Hanley types.

Intermittency of Application.

From the time when Frankland recommended intermittency in the application of sewage to land, as the only means whereby a practically complete purification could be secured, almost up to the present time, when quite a different method of purification is making its way, an intermittent application has been considered an essential requirement of the process.

Watson, for his sprinkling filters at Birmingham, does not consider it so, in the same sense as Frankland, but rests his beds about a fortnight per annum, only to regenerate them with an effect similar to that of raking sand beds. He sees no advantage in intermittency of application, but admits that the final word has not yet been said.

On most of the European coarse-grained filter beds, however, intermittency is practiced. Their examination has suggested to me that the advantage obtained thereby may perhaps not be due to the intrinsic merit of intermittency, but to the necessity of compensation for some other factors not sufficiently appreciated.

One of these factors was the lack of sufficient bacterial surface, causing the deficiency in area to be made up by frequent or lengthy periods of rest and exposure to air. Another factor was the insufficient supply of air to continuously exact the maximum amount of work from the bacterial film. Certainly the balance of these forces has in practice not yet been fully recognized, at least to the extent necessary to determine its time relation to cost.

More light will no doubt be thrown along these lines at the various experiment stations, and quantitative figures will be furnished by the aid of which the financial aspect can be better judged.

It has been demonstrated that sewage filtered through sand requires an intermittent dosing, to permit sufficient air to enter the pores and oxidize the organic matter which the sewage has left within them. It is likewise known that river water, filtered through sand and holding in solution a sufficient amount of air to oxidize the smaller amount of organic matter contained in such water, is equally well purified when the flow is continuous. Therefore, whether or not we should require intermittency of application for water or sewage, depends primarily upon the quantity of oxygen available and brought into contact with the bacterial surface.

In order to fully appreciate the subject of intermittency, it seems to me that we should divide it into two general classes, first, where it is essential to the purification, and secondly, where it is incidental to the distribution and non-essential to the oxidation. Intermittency is essential when there is a deficiency in the quantity of available oxygen after the sewage has been in contact with the bacterial film, and where there must be furnished a fresh supply of air to replenish the film. It is not essential where the air supply is abundant at all times.

Filters with Intermittent Air Supply.

To this class belong the well-known intermittent sand filters that have been in use for about forty years. A dose of sewage is flooded upon a sand bed. After a sufficient quantity has been delivered, the flow is turned upon another bed and the sewage practically fills the pores and slowly percolates through the sand to the subdrains. In so doing it draws air after it from above the bed into the interstices which have been partially vacated by the draining sewage. The bacterial film is thus revived, and when sufficient oxygen has again been absorbed by it, as Dr. Dunbar has well explained, the filter is ready for another dose.

The success of this method caused Dibdin, in England, to suggest another method, which he called purification by contact beds, and which he strongly advocated on economic grounds. The action is also dependent upon an alternative air supply. Such beds have been extensively used, the largest works being those built for the disposal of the sewage of Manchester, England.

A bed of broken hard stones is filled with sewage. The surfaces of the stones become covered with a bacterial film, which absorbs the organic liquids and expels the oxidized products. The sewage is drained out after a sufficiently long period of contact with the stone surfaces and their bacterial films, so that fresh air again can be drawn in and supply the film with oxygen for the work to be done at the next filling.

The period of contact is much shorter than that in intermittent sand filters, in which the smaller pores permit of but a slow percolation. The larger pores of the contact bed allow of a more rapid filling and emptying. The shorter time of contact was nevertheless sufficient to allow the purification to reach the stage of non-putrescence, which answers for many cases. Therefore, the relative usefulness and economy of contact beds, requiring much less area of land, became apparent.

The oxidation of the organic matter being chiefly effected during the period of aeration, it is customary to lengthen this period as much as possible, and both fill and empty rapidly. The beds should therefore not be too large. One-half acre is the maximum at Manchester and 4 ft. is usually the greatest depth. It is not unusual to allow, roughly speaking, one hour for filling, one hour for emptying, two hours for contact and four hours for aeration, making three charges per day.

Not knowing the exact necessary physical relation between the extent of bacterial surface, the amount of air supply, the thickness of oxidation and degree of purity to be produced, close estimates of required capacities could be made. It was found that a simple contact was insufficient in practically all cases of treating sewage, and a second one, accomplished by another bed, was necessary. Even a third bed has been occasionally used, thus giving triple contact. This has produced a very satisfactory effluent. With each fresh contact between the sewage and the rejuvenated film, a further oxidation of the same sewage takes place.

In a single ripe contact bed, as is usually built, unless the sewage is very dilute, the oxygen absorbed by the film is insufficient to produce a non-putrescent effluent. Even for the average American sewage two contacts would appear to be necessary.

It was found that the size of the grain in contact beds had to be quite small, much smaller than in most sprinkling filters. The smallest particles are generally not less than ⅛-in. in diameter and the average not over ½-in.

It seems that by estimating the area of the bacterial film that is available in contact beds, by realizing that they are utilized not continuously but intermittently, thereby reducing the time of their action at least by one-half, these results may be readily explained.

The air drawn into the pores of a contact bed does not act as effectively upon the mass of liquid which subsequently fills the pores, as it does when the liquid percolates through a sprinkling filter, as a thin water film percolating over a bacterial film. All liquid, therefore, may not get into contact with the bacterial film of a contact bed; certainly not while the bed is resting.

When filling or emptying, the rapidity of motion through the pores is greater than in a sprinkled bed, and the inevitable result of remaining in contact with the material long enough to allow the suspended particles to be drawn to and adhere to the bacterial film, will be to solidly close up the pores with mud.

It will also be seen that the contact process necessitates a great regularity in the dosing, so that the filling and draining occurs at regular intervals. Automatic appliances are therefore used and are essential.

The fact that the beds must retain the sewage necessitates a water-tight construction and therefore an expense greater than required for other filters.

Another objection, though not always considered so, is the gradual closing up of the pores within a few years.

The same reason therefore exists for discharging a clarified liquid upon these beds, as upon other beds, and, if the cost of doing so is not greater than the cost of cleaning the material, the sewage discharged upon contact beds should have a preparatory treatment. Dr. Fowler believes that experience at Manchester proves cleaning to be cheaper, while others believe that prior clarification would cost less.

In view of the disadvantages detailed, contact beds are not generally considered with favor in Europe and they are now being supplanted by sprinkling filters, chiefly on economical grounds.

The only decided advantage with which contact beds can be accredited, is one which sometimes justifies their building, even at an increased expense. As the sewage always remains at least several inches below the surface of the bed, it thus obviates the stench which necessarily accompanies the process of sprinkling. At Hampton, no odor whatever is noticeable at the beds. Sprinkling filters, to be equal in this respect, must be enclosed and the odorous air purified. Another advantage is the comparative ease with which small plants can be operated.

Filters with Continuous Air Supply.

To the class of filters in which the bacterial film is given a continuous air supply, belong the sprinkling filters of all designs, whether having

fixed nozzles, or revolving, or traveling distributors.

If we have a bacterial film of the area and thickness necessary to effect the required oxidation, and well ripened by being stocked with nitrifying bacteria; if we have the necessary air supply at all times to furnish the needed oxygen; if we supply the sewage practically without suspended matter; and, finally, if we so construct the filter that the time for percolation will be sufficient to effect the required oxidation, all as discussed above, then the factors are supplied for a successful continuous and economical operation of the filter.

In the present state of the art all these conditions are not yet perfectly met. Meantime, it is therefore proper to provide, as for all practical engineering work, a sufficient factor of safety.

In making a design, such a factor means a provision for an excess of bacterial surface and of air supply. In operating the works, the factor of safety will be a brief rest of the bed, when there has been temporarily a deficient air supply; when, as in Birmingham, there has accumulated too much bacterial slime; and when the time of percolation has been too short to allow of a sufficient oxidation of some of the more resistant, putrescent sewage matter, irregularly retained in the bed.

In England, filters having a continuous air supply have been curiously named intermittent continuous filters. A moving distributor and a dosing fixed sprinkler discharge continuously upon the whole bed, but intermittently upon parts of it. They have not the same intermittency as described above, but merely afford a convenient way of continuously spreading the drops as uniformly as possible over the whole area.

The moving distributor delivers upon the bed streams of sewage ¼-in. or more in diameter. Its continuous motion gives it uniform distribution. The spatter spreads the sewage laterally and thus wets the stones up to the line wetted by adjoining spatters.

Fixed sprinklers deliver finer streams and the dosing causes a more uniform distribution.

In all cases this continuous though intermittent application is a matter of minutes, only, and is devised solely for the purpose of getting a continuous and uniform distribution. The same result could be secured if sewage, as already mentioned, were to drop continuously and uniformly from stationary apertures upon a filter bed used for the deferrization of water. Contact beds require an intermittence of hours and sand filters of days, but in both cases for the purpose of aeration and not distribution.

Occasionally the charging both of moving and fixed sprinkler plants is so arranged that periods of several minutes rest are given after every dose, and that the discharge when sprinkling is greater than the permissible average rate per day, and must therefore be balanced by corresponding rest. This arrangement is advisable in winter to conserve the heat and generally to have thicker streams to prevent clogging of orifices, but should not be necessary for aeration.

Least Size of Grains of Filter Material.

In the early part of the present discussion it was suggested that the average size of grain for filtration should be considered with reference to the required bacterial surface and depth of bed. There is another important difference now to be considered which determines the least size of grain.

It is evident that a clear river water can have its dissolved organic matter oxidized in passing through a slow sand filter when this has grains of very small size. Two objects are sought: first the bacterial purification, and, secondly, the clarification of the water by straining out the suspended matter. Both are accomplished by fine-grained sand.

In sewage filtration there is the important difference that both the dissolved organic matter and (particularly) the suspended matter are so much greater that they form the most troublesome part of sewage purification.

The least size of grain that can be used in a sewage filter is therefore dependent upon the amount and character of the suspended matter that will reach the oxidizing bed. There is a close relation between the two, and it is practicable to determine the least size, if we know the degree of preparatory treatment required to remove the suspended matter.

If intermittent sand filters are used for oxidation, sand is the medium, and it can act at the same time also in the second capacity, namely, as a strainer, which leaves but little to be done elsewhere in further preparation. If percolating beds are used for oxidation, there is no means within the filter to furnish the clear liquid necessary for oxidation, and a special preparation is required.

We can divide filters into three classes, according to the purposes for which the least size of grain is required.

I. FOR STRAINING OUT SUSPENDED MATTER.—To this class belong the intermittent sand filters. The least size of grain for such filters is the one to give sufficient space between the grains for the desired rate of percolation. Nothing more need now be said than that ordinary good mortar sand generally indicates the most satisfactory size for crude as well as for settled sewage, in the latter case the rate of filtration being much increased.

II. FOR DISTRIBUTING SEWAGE UPON A SAND-BED COVER OVER A COARSE-GRAINED BED.—This filter is specially advocated by Dunbar, and has already been briefly described in its essentials. The sewage is given a preliminary settling and screening, so as to increase the filter rate. The sand cover has the double purpose of acting partly as a receiver and distributor of the settled and strained sewage upon the coarse-grained oxidizing filter beneath and partly as a clarifier. The size of the sand grains should be large enough to allow for the rate intended for the underlying filter. A very coarse sand with a trough distributor has been found satisfactory.

III. FOR FACILITATING THE OXIDATION OF SEWAGE.—As stated above, a filter or bacterial bed of coarse-grained material must receive the sewage practically clarified and the object of the filter should be confined, as nearly as possible, to mineralizing the dissolved organic matter through bacterial action. The average size of the stones will therefore depend wholly upon the relation required between bacterial surface, depth of bed and character of effluent, from which it can be roughly computed.

The minimum size, however, is governed by the following conditions: (1) The grains must be large enough to permit of free circulations of air through the pores. Practice has indicated that a diameter of ¼-in. is the minimum size for the thoroughly clarified sewage at Hanley.

(2) The grains must be large enough to prevent clogging, if the sewage is not thoroughly clarified. The minimum size, therefore, depends upon the available degree of clarification.

As will be seen later, sewage can be prepared in different ways, according to the demands made upon it, either by the oxidizing filter, as to whether it is a sand filter, a contact bed, or a sprinkling filter, or by the condition, as to whether the effluent is to be highly purified or to be left merely non-putrescent.

It is useless to expect a coarse-grained filter, as usually built, to turn out an effluent that is even non-putrescent, unless at least a coarse-screened and well-settled sewage is delivered upon it.

With only this degree of preparation it is a common occurrence that shreds and fibers of some length not only pass through screens, but also float in the settling basin and pass over to the filters. An average diameter of 1¼-in. (Birmingham) seems to be the least average size, with well-settled and septicized sewage, that would prevent such fibrous matter from bridging the pores and starting a clogging which ends in a pool.

Larger minimum sizes are advocated in Germany to facilitate better aeration, and therefore a final oxidation of the larger particles that with insufficient preparatory treatment may enter a filter bed and remain therein. Notwithstanding this advocacy, the tendency is growing towards a better preparation of the sewage, which will have the result of increasing the efficiency of the bacterial surface.

Between ¼-in. for thoroughly clarified sewage and 1¼-in. for well-settled and septicized sewage, seem to lie the minimum diameters of grain, which are used, after various degrees of preparatory treatment, for the different degrees of final purification.

It should yet be mentioned under this head that several European authorities have expressed the opinion that a uniformity of grain is far more important than the least size of grain, because it gives for the same amount of bacterial surface the freest circulation of air.

Finally, it may be added that the pooling which occurs in beds of small-sized stone is frequently caused by plant growth, which is independent of preparatory screening and settling of the sewage. Dr. Dunbar has found that this growth did not flourish when the sewage and beds were well aerated. This observation is consistent with that long-known fact that good ventilation practically stops such plant growth in sewers.

The appended table, mainly abstracted from the recent report of the Royal Commission on Sewage Disposal, gives certain elements of a few percolating filters in connection with the least size of grain.

It is apparent from the table, and is otherwise evident, that generally the preparatory treatment has to be carried to a high degree, in order to prevent clogging and leave the filter in a satisfactory condition. The opinion is gaining that a high-grade clarification in connection with smaller-sized grain is in the line of economy, and for this reason and purpose we see chemical precipitation used again in some places for preparing the sewage for filtration.

The table shows how nearly constant is the product of turbidity and rate, indicating that the more clarified the sewage the quicker it percolates. There is a point beyond which the saving in filter bed, due to the greater rate of percolation, will pay for the better preparatory treatment which makes the increased rate possible. Clifford in his paper also shows from his experiments how nearly constant is the product of time of percolation through clean beds and rate of sprinkling.

Further experiments in fine-grain filters should give us some closer figures, not only on the relation of size of grain to rate of percolation and amount of suspended matter, but also to the vegetable growths attached to the grains, which, under certain conditions, other than lack of aeration, have been found to produce clogging.

RELATION OF SMALL GRAINS TO RATE OF FILTRATION AND DEGREE OF PREPARATORY TREATMENT.

City.	Size of grains, ins.	Rate of filtration, U. S. Gals., per cu. yd. per day.	Suspended matter in tank sewage, pts. per mill.	Degree of preparatory treatment.	Condition of filter.
Hanley	¼ to ½	165	50	Thor'ly Clarified	Upper part probably requires washing every 4 or 5 years.
Salford	5/16 to ¾	200	30	Clarified	Good after 5 years. Top foot dug over or replaced after 3 or 4 years.
Leeds	⅜ to ¾	66	180	Septicized	Clogged in 2 years.
Birmingham	1¼ to 2½	100	80	Well settled and septicized	Good after 6 years.

Passage of Water and Bacteria Through Fine Capillaries.

Whether or not any of the following facts are of practical value to our subject remains to be seen. Some may be valuable and all are at least interesting, and as they certainly throw some light on the general subject, they are given for what they are worth.

The bacterial film or slimy colloidal coating of the grains of a ripe filter is a mass which is permeable to water and bacteria, and may be compared with a mass of capillaries. It is therefore interesting to see what light can be thrown upon our subject by considering the passage of water and bacteria through fine capillaries.

Contrary to a general belief that the smaller the capillary tube the longer is the time of percolation, it has been found in Europe and, I believe, also by Professor King at Madison, Wis., that water flowing through very fine capillary tubes has a more rapid velocity than in somewhat coarser ones.

This peculiarity may perhaps be explained by the fact that the water molecules which rest directly upon a surface do not move, roll or slide over it, but are held fast to it by adhesive attraction, and do not partake of the cycloidal and other movements of the water in the adjoining moving film. In a very small capillary tube, where the moving water has a very small diameter, it does not seem unreasonable to suppose that this free and moving water could slide upon the adhering film, which is too thin to be pulled off from the surface to which it adheres. If this water could slide, as upon a thin film of oil, its velocity would certainly be increased.

If the fact is true, then we may have a more rapid circulation, than we otherwise would imagine, of the dissolved and liquid sewage in the capillaries of the starchlike bacterial slime, and thereby obtain decreased efficiency as regards the storage capacity of the film in which, by absorption, most of the oxidation takes place.

Hofstätter* made very careful investigation at the Technical College in Dresden, regarding the entrance of bacteria into fine capillary tubes 0.006-mm. in diameter and less. He finds the number of bacteria voluntarily entering capillaries, when filled with fresh nutriment in solution, to be much greater than later after this nutriment has diminished. In the bacterial film surrounding the grains in a filter, percolating sewage would constantly have nutriment in solution and therefore tend to maintain a uniform, and when favorable, a maximum condition for growth.

The time during which a water filter is penetrated by bacteria he found to be dependent in a great degree upon their size and mobility, therefore indicating a pretty general distribution over the field of nutriment within the filter.

Bacteria do not of themselves enter capillaries of a diameter less than 0.0016-mm. in diameter, either when filled with a dissolved nutriment or not. Nor would water under pressure crowd, nor an exhaust draw, bacteria into them. The active bacteria are therefore located either in larger capillaries, where they also have a more ample field to effect oxidation, or they are held to the exterior of the film by adhesion and can absorb the dissolved organic matter from the passing and percolating sewage.

Gruber† demonstrated that cholera and typhus germs pass through filters only if dissolved nutriment had been added to the water. He also found that only such bacteria would pass through a filter as could find therein food and other conditions suitable for propagation. This was the case with ordinary water bacteria which he, as well as others since, often found more abundant in the effluent than in the influent water of filters.

Gruber also finds that ordinary river water has too little nutriment for cholera and typhus bacteria to make their propagation in such rivers possible.

Schöfer‡ claims to show in the following manner that cholera and typhus bacteria do not multiply in a water filter. Such bacteria were placed in a filter charged with sterilized water. None of the pathogenic bacteria appeared in the effluent until after dissolved nutriment had been added to the water, and they disappeared again when this nutriment was exhausted.

*Erich Hofstätter, C. E. "Das Eindringen der Bacterian in feinste Kapillaren." Archiv für Hygiene, 1905.
†M. Gruber. "Gesichtspunkte für die Prüfung und Beurtheilung von Wasserfiltern." Zentralblatt für Bacteriologie, 1893.
‡H. Schöfer. "Uber das Verhalten von pathogenen Keimen in Filtern." Zentralblatt für Bacteriologie, 1893.

We might expect a different conclusion to be reached in the case of a sewage filter, where the sewage contains a large quantity of liquid organic matter, which, if it has a suitable nutriment, would encourage propagation, so that, as in the case of water bacteria, possibly also cholera and typhoid bacteria could be more plentiful in the effluent of a sewage filter than in the raw sewage; thus making in such a case, a filtration of sewage of no sanitary advantage over a suitably devised discharge of the same into a river which is not used directly for a drinking water supply.

It is hoped that reliable experiments may be made to ascertain under what ordinary conditions such a result is possible.

Annual Convention of the American Foundrymen's Association.

The annual conventions of the American Foundrymen's Association and the American Brass Founders' Association were held jointly at Cincinnati on May 18 to 21. The meetings were held in a room at the Music Hall, the main hall being occupied by an extensive exhibit of foundry machinery and supplies. The combined attendance of members, visitors and exhibitors was very large, and there was a fair attendance at the business meetings. The weak point at these meetings was in the discussions, many papers receiving no attention in this way, while most of the discussions consisted simply of requests for additional information. Some papers of more than ordinary interest and importance were presented, notably those on the various processes of melting steel for castings, the continuous melting and pouring of metal, and the use of permanent cast-iron molds instead of the ordinary sand molds.

At the opening session on May 18, Mr. L. L. Anthes, President of the Foundrymen's Association, delivered an address in which he advocated industrial education for the younger generation, and an education also that will tend to raise foundry practice out of its many ruts and old-fashioned methods, and put it on a more modern and scientific basis. He suggested that machine molding has not been used as extensively as it should be, owing largely to the prejudice and backwardness of founders, the failure to provide the necessary auxiliary facilities, and the lack of understanding of foundry methods on the part of inventors. He advocated the establishment of a foundry laboratory for investigational work, under the direction of this association and the National Founders' Association. This might be made a department of some technical school. Mr. W. R. Webster, Vice-President of the Brass Founders' Association, followed with a short address, in which he suggested the adoption of standard methods of analysis for brass and alloys.

The report of Dr. R. Moldenke, Secretary of the Foundrymen's Association, showed a membership of 724. The receipts and expenditures for the year 1908-09 were over $2,660, leaving a balance of $7.94. The research work inaugurated by the association has been continued, mainly in relation to tests of molding sands and melting tests with coke-dust briquettes for the purpose of desulphurization. The special fund for this work now amounts to $433.

As to developments in foundry work we quote as follows from Dr. Moldenke's report:

> Two lines of foundry economy which have been studied during the past year are (1) the permanent mold, with elimination of waste, and (2) continuous melting, with an increase in output of existing plants. Before long we will find foundrymen understanding their cupolas better and manipulating them to suit their floor conditions, instead of the reverse.

ACCIDENTS AND INSURANCE.—The first subject taken up was the report of a committee on the prevention of accidents in foundries, which was read by Mr. Thomas D. West. It stated that while formerly all responsibility was apt to be laid upon the employer, there is now an increasing recognition of the responsibility of the employee when he is careless or negligent. In some cases where special protective appliances are provided (such as goggles to protect the eyes of grinders working at emery wheels) the men will not use these appliances. The principal suggestions as to the prevention of foundry accidents included the following:

(1) Weekly or monthly close inspection of all chains, slings, hooks, ladle bows, etc., by competent persons; annual or semi-annual annealing of chains. (2) Shops sufficiently lighted for proper work on dark days and light, with lights forceful enough to pierce steam and dust and yet give no sharp shadows on the floor. (3) The use of tramways to carry metal from the cupola to the floors; when this is not practicable, loose earth should be provided about the cupola spout, side-tapping being preferable. (4) Requiring carriers of molten metal to wear the proper kind of shoes to protect their feet, and providing goggles to protect the eyes of grinders.

In the discussion it was stated that a large proportion of the accidents happen to the least intelligent class of laborers, men who spend their leisure in the saloons and carry drink into the foundry. Reference was made to the proportionate number of accidents in "wet" and "dry" towns. Mr. West, however, thought that smoking caused more accidents than the use of liquor, as it makes men inattentive and careless. The report recommended that employees should be educated to see the necessity of protecting themselves by accident insurance. After the conclusion of the report, Mr. J. C. Chatfield presented a paper on "Disability Insurance for Employees."

INDUSTRIAL EDUCATION.—The first subject at the meeting on May 19, was the report of the committee on industrial education, which was presented by Mr. Paul Kreuzpointner. It pointed out the necessity of preparatory training, so that the shop school will not have to do work that should have been done in the public school. It proposed a system of industrial continuation schools, branching off from the seventh or eighth grade, in which the pupils would work up to 16 years of age. These schools could be supported jointly by the state and the community. It has been claimed that such general industrial education is not necessary, as the masses of industrial workers may never be called upon to utilize their knowledge, with the result that effort is wasted in obtaining the knowledge and discontent is caused by inability to derive material advantage from its use. The committee recognized the gravity of this aspect of the problem, but concluded that no amount of expensive supervision in the shop could be a substitute for self-directing reasoning on the part of the workers.

MELTING FURNACES. — Three important papers on the melting of steel for casting were read. We hope to publish abstracts of these in a later issue. Mr. W. H. Kane read a paper on "Air-Furnace Construction for Malleable Castings." While the cupola is cheaper as a producer, this advantage is more than offset by the inferior quality of castings made when there is direct contact between the fuel and metal.

PULVERIZED COAL FOR FOUNDRY PURPOSES.—This paper was by Mr. Richard K. Meade, who stated that this fuel offers many advantages (including economy) over gas for furnace heating. The paper described the preparation of the coal and the methods of burning it. This fuel is extensively used in cement kilns, and has been used for annealing furnaces and the furnaces for malleable castings. The author closed his paper as follows:

> The subject is one of such splendid possibilities that it is strange that metallurgical engineers have not given it very much more attention. It would seem that the up-to-date foundry could employ pulverized coal to great advantage.

Possible developments in the use of molding machines were discussed by Mr. Geo. Muntz in a paper on "Machine Molding versus Hand Molding." The continuous melting and pouring of metal throughout the day, instead of at the close of the day, was dealt with in two papers: Mr. S. D. Sleeth described the use of this system by the Westinghouse Air Brake Co., and Mr. R. H. Probert described its use in a foundry for general work.

A paper by Mr. D. S. Hawkins on "The Heart of the Foundry" dealt with the design of the

cupola and the action which takes place within the cupola during the melting of metal.

On May 20, only one business session was held, and most of the time was taken up by a paper of exceptional interest by Mr. Edgar C. Custer on "Permanent Molds." This described the use of cast-iron molds and cores instead of the usual sand molds and cores for pipe and pipe fittings, etc. The system is now in use, and the author was subjected to a rapid-fire attack of questions in regard to the details and results.

Of the other papers on the program, two related to cost distribution: "Foundry Costs," by Mr. R. A. Franklin, and "A Comprehensive Foundry Production Tally System," by Mr. C. E. Knoeppel. Each described a system in detail. A paper by Prof. John J. Porter, of the University of Cincinnati, dealt with "The Practical Value of Chemical Standards for Iron Castings."

CUPOLA PRACTICE.—Three of the papers related to cupola practice and its improvement, in addition to the paper by Mr. Hawkins, noted above. Mr. John C. Knoeppel, in a paper on "Modern Cupola Practice," suggested that the cupola has not received sufficient attention, in view of its important relation to foundry work. He favored frequent and small charges of coke to build up the bed (instead of larger charges at longer intervals), and also a mild blast. By operating in this way the melting is more rapid and uniform, while the metal is better and is less liable to vary from the desired chemical composition. Dr. R. Moldenke, in a paper on "A Suggested Change in Cupola Practice," favored making all charges alike (instead of a heavy first charge) and as small as possible, in order to hold the melting line as constant as possible. In this way the character of the molten metal is kept uniform and of better quality than when the melting line fluctuates under the influence of heavy charges at long intervals.

STEEL SCRAP IN THE CUPOLA.—Mr. C. R. McGahey described some equipments in the line of producing strong and yet elastic irons by the addition of steel scrap to the mixture.

The reduction of the total carbon by steel additions makes the resulting castings very much denser. If now the sulphur is controlled by hot melting and high enough manganese, and the phosphorus kept down (my best work has been with phosphorus about 0.230%) very serviceable castings are made.

The terms semi-steel and ferro-carbon, while used with good intentions, are entirely misleading. We do not convert the iron charged to steel or anything like steel, but simply dissolve the steel scrap added in the iron mixture, making it of higher strength. It is cast iron just the same.

BRASS AND ALLOYS.—Some interesting papers were presented relative to this department of the foundry industry. Two of these dealt with alloys: "The Patent Situation Respecting Alloys," by Mr. C. H. Clamer, and "The Tensile Strength of Zinc-Aluminum Alloys," by Prof. W. D. Bancroft. In a paper on "Brass Casting," also, Mr. G. T. Bragg stated that the increasing demand for alloys of certain definite physical characteristics is resulting in the development of a number of special metals. Too little is known about these, however, and attempts are made to produce new alloys for new requirements when those existing might serve the purpose. They should be standardized, and it is possible to keep the compositions very nearly standard if certain conditions are borne in mind. It was pointed out that the determination of the melting points and casting temperatures can be effected only with a pyrometer. At another session a paper on "The Operation of Industrial Pyrometers" was read by Mr. C. H. Wilson.

A paper by Mr. E. H. McVeen dealt with "Melting Brass Turnings in the Oil Furnace," and one by Mr. W. M. Corse with "The Manufacture of Red-Brass Ingot." Mr. F. W. Reidenbach, in a paper on "Waste Heat," suggested the utilization of heat from the melting furnaces for such purposes as generating steam for light power purposes, heating core ovens, or heating water for the lavatories. One member said he had used coils in the furnace stack to supply hot water for the wash rooms and for warming the foundry. Mr. Corse said that the General Electric Co. had tried this system, with a fan to blow the hot air and gases over the coils, but had abandoned it as unsatisfactory. In the discussion of the paper on cast-iron molds and cores (noted above) Mr. Custer said he saw no reason why the system could not be applied to brass foundry work.

The elections of officers of the two societies resulted as follows: American Foundrymen's Association: President, Arthur T. Waterfall, Detroit, Mich.; Secretary, Dr. Richard Moldenke, Watchung, N. J. American Brass Founders' Association: President, W. R. Webster, Bridgeport, Conn.; Secretary, W. M. Corse, Detroit. The next annual convention will be held at Detroit, Mich., in 1910.

Cast-Iron Molds and Their Effect Upon Castings Made in Them.*

By EDGAR A. CUSTER.†

The modern manufacturer is under the necessity of keeping down shop costs, and his constant endeavor is to substitute machines for manual labor where possible. It is this tendency that has of late years turned attention to the question of how far permanent molds for castings may be used to reduce the cost of production. It is not a new question by any means, but the information available is very meager. It is the purpose of this paper to give a full account of the conclusion formed after three years of constant work on the problem. It must be understood, however, that the paper deals solely with work that is applicable to permanent molds. The statements made, and the conclusions formed, are directed only toward that branch of the foundryman's art.

The ideal material for permanent molds would not chill the molten iron, would stand swift heating and cooling without disintegration, and would be capable of being machined or molded into the shape required. This material should be very nearly as hard as iron, quick to conduct heat, and of low specific gravity.

Cast iron has been the favorite medium, and so far, nothing has been brought forward that is so well adapted for foundry work. It has the advantage of being easily machined, and the added advantage that it is formed by a familiar process, while its possible disadvantages are more easily overcome than those of any other substance.

It is not much trouble to make and machine an iron mold, and we can calculate the expansion and contraction to a nicety. Its great drawback is its chilling effect. Some investigators make the claim that if the mold is heated to nearly the temperature of the casting when it is ready for removal, no chilling effect is perceptible; also that the molten iron should cool at the same rate in a permanent mold as it does in a sand mold. To both of these propositions I would answer that they defeat the object of permanent mold work, in that they destroy the permanence of the mold, confer no benefit on the finished product and set up a multitude of difficulties, such as core-crushing, shrinkage strains, and segregation.

But these two claims have been so persistently made that it seems advisable to treat them at some length. We are all familiar with the rapid disintegration of cast iron when kept at a very dull red heat; the rapid oxidization and the tendency to spawl and crack. When the heating and cooling extends through a range of 200 or 300° F. (and this must of necessity occur), the mold becomes useless in an incredibly short time. Again, the molten iron will not lay close to such a mold, and the resulting castings are far from perfect.

It has been conclusively demonstrated that mold distortions due to heat become permanent after a temperature of 900° F. has been passed, so that highly heated cast-iron molds seem to be out of the question. While there is no doubt that they would prevent chilling, the cost of such a method would be prohibitive.

Should the iron cool at the same rate in a permanent mold as it does in sand? The answer to this is most emphatically in the negative. The effect on the mold would be the same as maintaining it at a high heat, and the time lost in cooling would protract the process materially. Slow cooling would not improve the casting, nor would it prevent segregation. It would induce shrinkage strains, and in fact would be no improvement over the present sand-casting method, except that it would obviate sand ramming.

When we first contemplated using permanent molds it was considered a foregone conclusion that unless the interior of the mold was heavily coated with some inert substance, the casting would necessarily be chilled. For a time the molds were carefully coated after each pouring, but, in our efforts to gain time, this coating was neglected, and we noticed that no chill appeared, provided the casting was removed above a certain temperature. Following this lead we found that when the surface of the mold was practically free of any coating, no gases were formed by contact of the molten metal, and that chill could still be prevented by removing the casting at the proper temperature. When these facts were thoroughly established, our attention was centered on the possibility of removing the casting as soon as it was set. A few trials proved beyond doubt that molten cast iron does not chill until after the casting has set, and it was simply a question of reasonably quick work to produce castings not only perfect in form and texture but answering all the requirements for high-class marketable work.

The next step in this line of reasoning was that if the contact with comparatively cold iron on one side did not necessarily chill the casting, then contact with iron on both sides need not chill it. To demonstrate this point several thin sheets were cast between heavy plates and removed without chilling. This suggested the possibility of using metal cores, provided these could be removed before being caught by the shrinkage and immovably held or the casting cracked. Reasoning that cast iron does not contract until after it is solid, we believe that it would be possible to remove a core before such contraction occurred.

This was tried first on a T-shaped pipe fitting, the entire core being made of cast iron, in two parts; one part for the main body and one part for the branch. It proved to be not only possible but very easy to withdraw the core, provided it was done when the casting was at the proper temperature. Nor was the allowable time, for the withdrawal of the core so short as would be expected. In fact, it was necessary to wait a few seconds after pouring, before removing the core.

If, then, an iron core could be easily withdrawn from a tube 1 ft. long, it was possible that it could be withdrawn from a tube 5 ft. long. This was attempted, and repeatedly accomplished, a 4-in. pipe 5 ft. long being cast on an iron core and the core removed before being gripped by the contraction of the pipe. We found by these trials that no gases were formed other than those from the air in the mold, and if this air was allowed free vent no trouble was experienced in filling a mold of any shape or size, and in removing the resulting casting at such temperature as to avoid white chilled crystals.

The next step was to determine what size and shape of mold was best adapted to this process. This was a long and tedious investigation, most of the results obtained being of a negative character. It is almost impossible to formulate any set rule as to size and shape of mold for various castings. The one general rule of allowing a surplus of metal in every case seems the best practice. This is, of course, very indefinite, and experience only will show what is best. The mold in which a trap was cast weighs 1,700 lbs., and the 2-in. tee mold over 500 lbs. The advantage of providing a large bulk of iron is too great to be ignored when it is considered that the objects desired are not only to swiftly remove the heat from the molten iron but also to provide enough metal to store heat and resist the tremendous strains imposed.

In using these molds we take no precautions against shrinkage. We depend altogether upon the fact that chilling molten iron swiftly to the point of setting makes castings that are homogeneous, and thus the shrinkage strains due to irregular cooling are reduced to a minimum. The main object to be accomplished is to secure rigidity of the mold in all its parts—there is always time enough to remove the casting and retain the shape given it by the firm, unyielding surface. A mold that has thin walls (1½ or 2 ins. thick) will spring away from the molten iron under the influence of the intense heat, and the casting will invariably follow the spring.

Molten iron, like water, moves in the line of least resistance. Its peculiar property of increasing in bulk when passing from the molten to the solid state makes it possible to get a casting that fills every crack and cranny of the mold so long as this tendency to swell is successfully resisted. This same mass of iron in the mold, by reason of its rigidity and its capacity for quickly transmitting and storing heat, will greatly lessen the liability to cracks in the mold cavity. The only place where any deterioration sets in is where the molten iron strikes in the gates, and our experience has shown that we can safely neglect this item.

How long a cast-iron mold will last has not yet been determined. So far, we have made over 6,000 pieces in a single mold, and it is in better shape now than when we started. There is no reason why its life should not be indefinite, although there must be a point of time and service when the cast iron has reached its ultimate capacity for work. Our statistics show that the life of the mold depends, not upon the number of pourings but upon the number of times the mold is allowed to become entirely cold and then reheated. Continuous pouring, when correctly timed so as to preserve a generally even temperature, has but a very slight tendency to crack the mold. It is only when it is allowed to cool that the cracking becomes at all noticeable, and then only in the gates.

We have found that a good casting can be made in a cold mold without any trouble, provided the mold is perfectly dry. But the tendency of the iron to condense moisture from the atmosphere while heating up is so great as to make it almost impossible to get a good casting unless the pouring is done rapidly, so that the mold will be filled before the moisture is deposited upon

*Abstract of a paper on "Permanent Molds" read at the annual meeting of the American Foundrymen's Association, held at Cincinnati, Ohio, May 18 to 21, 1909. A number of samples of pipe, pipe fittings and other castings made in cast-iron molds (instead of the ordinary sand molds) were exhibited at the meeting.

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the face of the mold. In a perfectly dry atmosphere, with a cold mold, the iron pours readily and makes a very fine casting. The only reason it is desirable to have the molds warm is that they will keep perfectly dry. We would much prefer to do all our work with a mold at a temperature of not more than 125 to 150° F. As a general rule the first casting is not a very good one, but after the casting has warmed up the mold, there is no further difficulty.

In order to preserve an even temperature in the mold it becomes necessary to put enough weight into it and pour the castings at such intervals that the temperature will not rise over a certain number of degrees. For instance, we found that casting a 4-in. pipe weighing 65 lbs. into a mold weighing 6,500 lbs. every seven minutes, does not raise the temperature of the mold to more than 300°. This matter of heating depends altogether upon the thickness of the casting, and the molds must be designed with that particular point in mind.

That a permanent core can be used in a great many cases has been shown. Its use is necessarily limited to castings in which the core is either in a straight line or is in a regular curve. Combinations of straight lines, such as in T's or Y's, or double T's or double Y's or straight pipes, are especially adapted to this feature. When the core is in the shape of a regular curve, or combination of a straight line and regular curve, it can be made in two or more pieces and easily withdrawn from the casting. This can be done in the case of L's, or sweeps. Irregular curves or cores that would be destroyed in removing them from the casting are, of course, not possible.

We have found that the best metal for these cores is ordinary cast iron, and that the same method of procedure must be carried out for the core as with the mold. There is plenty of time to remove the core and open the mold and yet have the casting without any hard spots. The use of permanent cores suggests the possibility of a machine for duplicate work that is to be made in large quantities, and this machine can be practically automatic in its operation. Pipe fittings, chain links, elevator buckets, etc., might possibly come under this class. This is, perhaps, looking rather far into the future, but it is the logical outcome of the successful carrying out of the principle involved.

It has been found easy to remove a 5-ft. core in the manufacture of cast-iron soil pipe. It should be just as possible to remove a 12-ft. core from a water-pipe. It is only a question of apparatus large and powerful enough, and removing at the proper speed. Cores made of steel and wrought iron have been tried, but give very poor results. The cast-iron cores require considerable attention for the first few pourings, to prevent burning and distortion, but after a few castings have been made the iron seems to become seasoned, and after 50 or 100 castings have been poured, very little care need be taken in regard to overheating the arbor or burning it by the impact of molten iron.

Soft cast iron seems to be the best medium for both molds and cores. It cracks less, and is not liable to distort, as is the case with a casting made of low-silicon or very close iron. It may be that this is due to the fact that a high-silicon iron melts at a much higher temperature than iron containing a low percentage of silicon, and consequently requires a higher temperature to reach the point at which it softens.

The conclusions arrived at as the result of these investigations may be summarized as follows: Any casting that can be poured in a sand mold can be poured in an iron mold. If the iron is hot enough to run in a green sand mold it will surely run in an iron mold. Iron that is suitable for radiators or fittings, or brakeshoes, or any other class of duplicate work that is made in the sand, will be suitable for the use of permanent molds. The same experience that shows the foundryman what is best for sand molding can be utilized in permanent mold work. It is true that a somewhat wider range of iron can be used in permanent molds for the same class of work than is the case in sand molding, but any change from the general practice in selecting iron for any particular class of work must be made with a great deal of care.

It is, of course, a subject that demands close and incessant study, and every manufacturer who wishes to use permanent molds must give the same care and thought to this method that he gave to previous methods employed. When the high-class engineering and technical skill is applied to the permanent mold that has been devoted to the molding machines now in use, we may expect to see some very wonderful developments in the foundry line.

When using permanent molds, the iron as it comes from the cupola should be very hot, and should never be allowed to stand any length of time before pouring. The first element it loses in cooling is carbon, especially if there is considerable silicon in the original charge. Iron at 2,100° F., with 2.5% silicon, will not hold as much carbon in solution as it will at 2,400° F., and it is the carbon we wish to preserve. In fact, it is almost impossible to make a very thin casting in an iron mold, with iron containing 2.75% silicon and low in phosphorus and sulphur, unless the iron is very hot. Our work has shown us conclusively that the best results are obtained with iron containing over 3% carbon and about 2% silicon. Again, the higher the temperature of the initial iron, the more time there is for the removal of the casting, and the longer shrinkage is delayed. The importance of hot iron is therefore evident, although there is but little loss of carbon when the silicon does not exceed 2.25%, and ordinary diligence is used in pouring.

Some care must be exercised to prevent the casting sticking in the mold. It is sufficient to coat the mold occasionally with a mixture of thin oil and graphite. There is no virtue in any of the many coatings recommended other than keeping the molds smooth and preventing the castings from sticking. None will prevent chilling, unless laid on in such quantities as to form a substantial wall of inert material. The best way to prevent a chill is to take the casting away from the mold before the chill sets in.

That this chilling does not take place until after the iron has been set sufficiently to handle is demonstrated by a small sample casting made specially for the purpose. One side of this casting is soft and the other is chilled. The quality of the iron in the unchilled portion is of the highest character, and can be machined with facility. This sudden chilling to the point at which the molten iron sets produces an iron that is as nearly homogeneous as it is possible to obtain. That it is entirely free from shrinkage strains is shown by a casting that was taken from the mold at a bright red heat and thrown into cold water. It is absolutely sound and free from all cracks, surface or otherwise.

Now, what peculiar molecular action is set up that produces this result in an iron that when cast in sand exhibits all the defects we are accustomed to see in sand molding? To get at this explanation we must begin with the great unmeasureable force of heat contraction and expansion. No one knows what pressure per square inch is exerted when molten iron cools. This force is always greater than the tensile strength of the material under treatment. If, now, molten iron be subjected to this enormous force exerted through the mold swiftly robbing it of its heat, it probably follows that the molecules are crushed together with an enormous pressure. Since this action is a matter of a few seconds at the most, there is no chance for segregation, and the impurities remain in the same relative position in the casting that they occupied in the molten iron.

That this peculiar action continues after the casting has been taken from the mold is shown by small globules of iron that have been squeezed from the casting as it cooled. It is further shown by a bar of 1½-in. iron that was taken from the mold at a bright yellow heat, with the interior still molten. Excrescences on the top were formed as the bar cooled in the atmosphere, and the broken section showed that the bar is of equal hardness throughout.

Now, let us go a step further. It has been found that iron when cast in an iron mold and removed as soon as it sets, possesses some unusual properties. For one thing it will take a temper, and when tempered will retain magnetism. If the casting be taken from the mold at a bright heat and suddenly quenched in cold water, it has all the cutting power of a good high-carbon steel. This result is invariably obtained whether the iron be high or low in silicon, phosphorus, sulphur or manganese. There is no evidence of what we generally speak of as "chill"; no white crystals are shown. In fact, an iron that chills white first in the mold and is then quenched in water will not harden in the manner described but will crumble when applied to the emery wheel.

The fact of the matter is simply that chilling molten iron swiftly to the point of setting, and then allowing it to cool gradually, produces a metal that is entirely new to the art. It has all the chemical characteristics of cast iron, with the exception of combined carbon, and it also possesses some of the properties of high-carbon steel. We have been taught that steel will not take a temper when it contains a very appreciable amount of free carbon. Yet this piece of cast iron, that has 0.44% combined, and over 2% free carbon, has been tempered repeatedly and will do better service in a lathe than a very good non-alloy steel. Once this peculiar property is imparted to the casting, it is impossible to eliminate it except by remelting. A bar of iron so treated can be held in a flame until the metal drips from the end, and yet quenching will restore it to its original hardness.

The character of the iron before being quenched, is very fine, close-grained and yet it is easily machined. In all this work there are no blowholes, and any dirt that enters into the piece must come from the ladle.

All the carbon in molten iron is in solution, and exists in the combined form. Now, if molten iron be instantly cooled to 1,000° F. all the carbon will be held in the combined form; there will be no free carbon. If, however, it be instantly cooled to the point at which the iron sets, and then allowed to cool normally, the carbon will be in the combined form at the time of setting, but will change to the free form as the cooling progresses. This formation of free carbon is very rapid; the major portion present in the casting is formed within a few seconds after it is taken from the mold. The analyses below give a very fair idea of this action, the pieces in question being 6 × 1¼ × ½ ins.:

	C.C.	F.C.
Cast in sand and cooled normally	0.49	3.39
Taken from permanent mold at bri... yellow and quenched	0.27	3.59
Taken from permanent mold at ...bt red and quenched	1.50	2.42

It will be seen from this that ... of the combined carbon has been changed in the fe... conds required to cool from a bright yellow to the ...ht red. The free carbon in all these castings is not ...e form of graphitic carbon, as we usually see it i... ordinary cast iron, but partakes more of the character ... annealing carbon. It is probably this annealing carbon ... gives permanent mold castings their unusual strength ...d toughness.

Sand as a medium for making ge... castings will always hold its own. We have discov... nothing that is so cheap and so efficient, considerin... the vast range of work it is required to do. Its ... encies are well known; but so far, all efforts to ...rcome these deficiencies have been solely in the d...tion of shedding light upon the characteristics of the iron used.

We read a great deal about the ... of sulphur and of phosphorus, and we find that the... evils are not exaggerated when it comes to making ...stings in sand. But to my mind, the reason why phosphorus and sulphur are the bane of the foundryman's existe...e is not because of the mere fact that sulphur and pho...horus are present in the casting, but because in slow cooling in sand molds, sulphur and phosphorus segregate. Therefore, the great evil in cast-iron work is not so much the presence of impurities, but the fact that segregation allows these impurities to mass themselves and thus destroy the homogeneity of the iron.

Our experiments have shown that an iron containing 1½% phosphorus when cast in an iron mold is as strong as iron containing 0.4% when cast in the same mold. We can find no perceptible difference in the tensile strength under these circumstances. The same is true with sulphur at 0.1% and at 0.03%. It would seem, therefore, that the mere fact of the presence of sulphur and phosphorus in these irons is not deleterious when segregation is prevented.

It is not within the province of the sand mold to prevent segregation, and the remedy cannot be looked for from that point. Nor is it possible to prevent a certain amount of segregation in a permanent mold when the casting is so thick in section as to make the cooling comparatively slow. Fortunately, most of the duplicate work in this country to which the permanent mold is applicable is of comparatively small section; very little of it is more than 1 or 1½ ins. in the thickest part. When a casting is not thicker than this, and is made in a mold properly designed, there will be absolutely no segregation.

The formation and segregation of graphitic carbon is familiar to all, and its weakening effect upon cast iron is very well known. The casting made as above described, and containing free carbon that is thoroughly distributed throughout every portion of the iron and is not allowed to collect in large flakes or bunches, will be as easily machined and will have greater tensile and crushing strength than a casting made in a sand mold in the ordinary way.

The position the writer takes in this matter is that the evils of phosphorus and sulphur are due not to the fact that these elements are present in the casting, but to the fact that the slow cooling allows them to collect in masses. If segregation were prevented, a high-phosphorus or a comparatively high-sulphur casting would be just as strong as if these elements were low in percentage.

So far, we have discussed simply the use of the permanent mold as applied to the foundryman's art, with iron taken from the cupola. If permanent molds can be used with success in the foundry, and a system of continuous pouring be inaugurated which in duplicate work would obviate the necessity of having molders, why is it necessary to melt pig iron in the cupola? What could be more ideal than a series of permanent molds supplied with molten iron practically direct from the blast furnace? The interposition of a reheating ladle such as is used by the steel makers of to-day, presents no unusual features; and this ladle makes possible the treatment of the molten iron.

Modern practice has eliminated much of the uncertainty in blast furnace work, and it is not unusual to find these furnaces so equipped as to produce an iron that varies but few points from the quality desired by the foundryman. The molten iron we get from the blast furnace is much hotter than that obtained from the cupola, so that there is every reason to believe that the castings we would obtain would be of a better quality than when the pig is remelted in the cupola.

In our work we have conclusively demonstrated that it is immaterial whether an iron contains 1.75 or 3% silicon, so long as the molten mass is at the proper temperature, so that the high temperatures obtained from the blast furnace would go far toward offsetting the variations in the impurities. Given, therefore, a furnace properly equipped and properly handled, with the interposition of a reheating ladle, there is no reason why a very high class of work should not be obtained with the use of permanent molds. It lies with the blast-furnace owner to ascertain how far this thought can be carried out.

Andrew Rosewater.

The death of Andrew Rosewater, M. Am. Soc. C. E., City Engineer of Omaha, Neb., was noted briefly in our issue of April 22. On Friday, April 16, the day before his death, he showed no signs of illness and was in particularly good spirits on account of his having just been nominated Republican candidate for another term as City Engineer. He retired at about eleven o'clock in his apartments at the Paxton Hotel. Shortly after four in the morning, Mrs. Rosewater discovered that her husband was suffering from an attack of some sort and she at once summoned assistance, at the same time making every effort herself to restore him. Before the physicians arrived Mr. Rosewater died. His death is ascribed to heart failure.

Mr. Rosewater was born in Bohemia, Oct. 30, 1848, but came to this country at an early age with his parents, who made their home in Cleveland, O. Of his five brothers and three sisters, Edward Rosewater, founder of the Omaha "Bee," and one sister, Mrs. Feil, are the only others who have died. Andrew Rosewater was educated in the Cleveland public schools and his technical knowledge was gained by experience. In 1867, at the age of 19, he left Cleveland for Omaha as a rodman with the engineer corps engaged in the construction of the Union Pacific Ry.

His first connection with the engineering department of the city of Omaha was formed in the following year, 1868, when he was made Assistant City Engineer. Two years later, he became City Engineer and served in this position until 1875, when he became associated with his brother, Edward, as Manager of the Omaha "Bee." One year of the newspaper business appears to have been enough for him, as in 1876 he gave up the managership of the "Bee" to take charge of the construction of the Omaha & Northwestern Ry. Following the completion of his work for the railway, he became Resident Engineer of the Omaha Water Co. in 1880 and served in this capacity for about one year.

In 1881 he entered upon a second term as City Engineer of Omaha and continued in this capacity until 1887. It was during this period that he became a member of the American Society of Civil Engineers, Oct. 3, 1883, and about two weeks later he was married, Oct. 18, to Frances Meinrath, of Boston. Mr. and Mrs. Rosewater have always made their home in Omaha, although his work during the period from 1887 to 1891, when he was Consulting and Designing Engineer of sewerage systems for 25 different towns and cities, called him to many parts of the country. During the following five years, he practiced widely as a consulting engineer, participating in the planning of railways and other public improvements in Colorado and South Dakota. The great hoisting plant of the Homestake Mine at Deadwood was constructed under his direction. He was at one time called by President Diaz to advise regarding public improvements in the City of Mexico. In 1897, Mr. Rosewater again became City Engineer of Omaha and served until his death.

The University of Nebraska conferred on him the degree of Doctor of Engineering and Mr. Rosewater was the only engineer who ever received this degree from that university.

Among the men with whom he had worked, including even those with whom he differed in opinion, he won the reputation of being thoroughly trustworthy and sincere in adhering to what he believed to be right.

Notes from Engineering Schools.

STATE UNIVERSITY OF IOWA.—It has often been stated that a course in engineering is a better preparation for a business career than either the standard course in the classical studies or any of the special courses which have thus far been established which are supposed to deal with commercial matters. The State University of Iowa has issued a circular entitled "An Engineering Course that Prepares for Business," referring to a special course which it has established for the benefit of students who look forward to a commercial career and desire engineering studies to prepare for it.

The course is partly prescribed and partly elective, and differs from the regular engineering courses, apparently, in giving a greater amount of study in English and foreign languages and a larger proportion of elective studies, among which are economics and the principles of commercial law.

UNIVERSITY OF MICHIGAN.—A bulletin just issued by the Department of Engineering announces the establishment of six-year courses in engineering and in architecture, leading to the degree of Master of Engineering or of Architecture. The degree of Bachelor of Science is given at the end of four years of study and one summer session of eight weeks. The degree of Bachelor of Engineering is given on completion of the fifth year of work.

There are now seven distinct engineering courses given. Besides the well-known courses in civil, mechanical and electrical engineering, courses are given in chemical, marine and geological engineering and in architecture. The concluding 20 pages of the pamphlet give a biographical account of the various members of the faculty who have in charge the work of the Engineering Department, which is prefaced by the following statement:

> The instructing staff of the Department of Engineering of the University of Michigan is selected in accordance with the theory that no person is properly qualified to teach the technical branches of engineering who is not or has not recently been engaged in the practice of the profession, or in original investigation connected therewith. Accordingly, the members of the Faculty are expected and encouraged to carry on, in connection with their college work, a consulting practice and original investigations as soon as they reach the grade of assistant professor, and instructors are expected to devote their vacations and a whole year from time to time to practical professional employment. As a result, all are constantly adding to their store of knowledge and imparting fresh acquisitions to their students.

A RAILWAY ACCIDENT May 23 near Dehra, India, resulted in the death of ten natives and the serious injury of 14 others. A train of 16 freight cars ran away down an incline and collided with a passenger train, wrecking all the cars of both trains.

A CHURCH GALLERY IN PORTUGAL collapsed May 20 during a service, and fell with its load of about 200 people upon the crowded congregation below. Seven persons were killed and 35 others seriously injured. The church belonged to a monastery at Delgil near Lisbon.

THE "MAURETANIA," giant transatlantic steamship of the Cunard Line, lowered the westbound record by 13 minutes on the trip ending May 20, making it now 4 days, 16 hrs. and 53 min. The average speed recorded was 25.62 knots per hr.

A BASCULE BRIDGE COLLAPSED during erection at New Orleans, La., on May 18, causing the death of one workman and injuring four others. The bridge was being built to cross Bayou St. John at the foot of Esplanade Ave. It was a single-span through trunnion-bearing bascule, with the main trusses of the Warren type with vertical posts. During a test of the almost completed structure, while the movable span was being lowered, the upper chord parted nearly above the trunnion and the counterweighted end in falling into the pit, caused the casualties noted. The accident is now under investigation by City Engineer Hardee. Until his report is presented, no official account of the accident is available.

THE WATER SUPPLY SYSTEM OF SALT LAKE City, Utah, was reported, in dispatches published in the daily press last month, to be seriously damaged. Investigation shows the occurrence to have been only a trifling matter. We have received from Mr. L. C. Kelsey, the City Engineer, an account of the trouble which was the basis of these false reports.

The Parley's Canyon reservoir, one of the sources of the city's water supply, is filled both from Parley's Creek and from the Parley's Canyon Conduit and is emptied into the mains through the Big Cottonwood Conduit. Originally flood waters in the Creek were carried through the reservoir, but some eleven years ago, after a flood, a temporary wooden flume was built through which could be diverted the entire waters of the Creek, to be carried around the reservoir and to another outlet not connected with the city mains. There is also a 24-in. wire-wound by-pass conduit, which may be used to divert the water from the Parley's Canyon Conduit around the reservoir to the Big Cottonwood Conduit. For a considerable distance the by-pass is under the flume, which latter is in a very bad condition owing to insufficient maintenance. During the high water of April a portion of the flume and the by-pass conduit were washed away, and it became necessary to turn the flood waters of the Creek, ordinarily carried through the flume, into the reservoir. As this water was exceptionally muddy, it was decided to close the reservoir from the city mains and as the by-pass pipe was also destroyed for a short distance it was impossible to turn the water from the Parley's Canyon Conduit through that by-pass into the city mains. So for a short time the water ordinarily supplied through the Big Cottonwood Conduit was unavailable. There was, however, another source of supply amounting to about 19,000,000 gals. per day, (Salt Lake City's population in 1906 was estimated at 61,000), so the city's supply was ample. In case of fire, the Big Cottonwood supply would have still been available. The entire damage amounted to a few hundred dollars, the by-pass is now repaired and no further trouble is anticipated.

THE PENNSYLVANIA STATE HIGHWAY, extending east to west across the state, is not to be built after all. The bill providing for its construction which was passed by the legislature was vetoed by Gov. Stuart. Work on highway improvement will be carried on by an appropriation of $2,000,000 to be available during the next two years, which is about the same amount that the state has expended on the work during the past six years. A bill was also passed extending the aid of the state in a certain amount of road improvement work carried on by townships.

SYDNEY HARBOR CROSSING.—The London "Engineer," May 14, states that the last "Royal Commission" on the crossing of Port Jackson, Sydney, New South Wales, after sitting for some months, has reported in favor of three tunnels. The problem is to convey 25,000,000 passengers annually across a wide and deep tidal channel crowded with shipping and ocean liners. There is a sharp rise on the north shore and the channel has a depth of 80 ft. This channel cuts off the city and its southern suburbs from the northern suburbs. It is necessary also to have some connection between a railway on the north shore and one entering Sydney from the south. There is in addition considerable vehicular traffic. At present the passenger service is by fast steam ferries and separate vehicle boats. There is no chance of increasing the ferry service on account of the lack of wharfage on the Sydney side and because of the danger to shipping through congestion of boats.

The dampness and heat of the climate during several months of the year has been believed to make any long tunnel ride uncomfortable so that the popular demand has been for a bridge. The deep channel and steep approach of the tunnels have also favored the popular project. The question has been before the public for many years and both bridge and tunnel projects have been discussed. Until recently it has seemed certain that a huge bridge would be built. Designs were solicited in 1900 (see Eng. News, Feb. 22, 1900; March 8, 1900, and July 25, 1901). Plans were accepted in 1904 (see Eng. News, Sept. 22, 1904), but the project was shelved because of financial difficulties.

The successful construction of the Detroit River tunnels (Eng. News, Oct. 31, 1907, and Sept. 24, 1908), it is said, has been largely influential in causing this last "Royal Commission" to favor the tunnels. By the Detroit method of sinking shells and covering them with concrete the trouble with the deep channel can be largely eliminated. One of the proposed tunnels will connect the railways, north and south. Two other tunnels will provide for the vehicular and tramway traffic. No provision seems to have been made, however, for so connecting the tunnel tramways with existing lines that a passenger's journey may be unbroken between a starting place on one side of the channel and a destination on the other.

Another factor influencing the report in favor of the tunnels is said to be the possibility of building the most needed tunnels (for tramway and vehicular traffic) at once and the railroad tunnel later, when the financial conditions permitted. In contrast, with a bridge the heavy expense of providing for all classes at once would have to be assumed. The cost of a bridge is now estimated at about $12,500,000, whereas the complete tunnel project involves only about $8,750,000.

PURE LOW-CARBON STEEL TO RESIST CORROSION.—"It appears to be the opinion of a number of metallurgists that carefully made open-hearth steels, in which the ordinary impurities have been worked down to a minimum, with especial care in the heat treatment, are much more resistant to corrosion than the ordinary run of merchant steel. There is now being manufactured in several rolling-mills in the United States an extremely pure metal which contains, according to analysis, about 99.95% iron. The only impurities which this metal contains are sulphur (0.019), phosphorus (0.004) and carbon (0.026). This pure iron is manufactured in basic open-hearth 50-ton converters, and is smelted from pure pig iron and carefully selected high-

grade scrap. There is no mystery about its manufacture, everything depending from start to finish on the heat treatment which the metal receives. In the opinion of the author resistance to corrosion is attained largely by a study of the proper heat treatment of the metal and of the amount of working which it has received, both in the hot and cold rolls. Up to the present time this pure iron manufactured by a steel process has been used for the preparation of sheet and plate only. It has been demonstrated, however, that wire can be made from it. Although it is apparent that a metal of this character could not be used where a tensile strength in excess of 40,000 to 50,000 lbs. per sq. in. is required, there are certain purposes for which it is well adapted, such, for instance, as roofing, sheathing, culverts, pipes, etc."—A. S. Cushman in "The Preservation of Iron and Steel," Iron and Steel Institute, May, 1909.

A 533-FT. STEEL ARCH BRIDGE across the Song-Ma, an inlet from the ocean, in Tonkin, China, is described in the May 8, 1909, issue of "Le Genie Civil." This bridge is a part of the railway line between Hanoï and Hué and was built by the well-known French construction engineers MM. Daydé and Pillé. The total length of the bridge, measured between end pins is 532.8 ft. The width, c. to c. of the two arch ribs, is 32.8 ft. The roadway carries a 1-meter (3.28 ft) gage, single-track railway with a timber driveway or sidewalk on each side. Each arch rib is made up of a three-hinged arch, tied together above the springing line with a tie-rod, and supporting by hangers the roadway. The rise of the arch is 82 ft. from tie-rod to crown hinge, and the tie-rod is 12.8 ft. above the grade of the springing line hinges. Each rib is made up of two parts, the upper and the lower, joined together by vertical and diagonal posts forming 18-ft. panels. At the crown these ribs are 9.7 ft. deep, gradually enlarging to 30 ft. at the spring. As noted, there are three hinges, but on account of the tie-rod, the arch is vertically bearing, fixed at one end and moving on a nest of rollers at the other. The strait over which the bridge is built is subject to high and sudden floods so that no falsework was placed in the river. The erection was carried on from a cableway suspended from braced towers at each abutment.

THE RESISTANCE OF PAVEMENTS TO TRACTIVE effort has recently been investigated in the city of Toronto, Ont., and reported to the Canadian Society of Civil Engineers in a paper by Mr. A. C. D. Blanchard. All experiments were made with a good, steady team of horses, weighing 2,940 lbs. and drawing a truck weighing 2,710 lbs., with a load of 8,570 lbs. Between the horses and the truck there was placed a standard dynamometer which was read by an observer on the truck, at stated distances paced and called out by the notekeeper walking alongside. Observations were made on wet and dry streets of varying grade and paved with asphalt, bitulithic, brick, cedar block, granite block, and treated wood block. From the figures so determined curves have been plotted on grade of street as an abscissa and tractive resistance as an ordinate. For dry streets these curves, which are straight lines, show the brick paving to have the least resistance, the others following in the order: treated block, bitulithic, cedar block, granite block, asphalt. These lines all show a fairly uniform rate of increase of resistance with grade, except that the granite block seems to increase its resistance with grade somewhat more sharply than the others.

On wet streets, the order of tractive resistances, beginning with the lowest and going up is: bitulithic, asphalt, treated block and cedar block. Wet brick pavements were not tested. The wetness of the streets seems to show small effect on the resistive powers of the pavement. The high place of the asphalt in the list of dry weather records is due to, no doubt, the fact that dry weather is hot weather and the asphalt pavement then is rather a soft mass into which the wheels of a wagon sink. On wet, and therefore cold and hard, asphalt pavements, the asphalt shows a very low resistance.

Personals.

Mr. D. C. Fenstermaker, Assoc. M. Am. Soc. C. E., has been appointed City Engineer of Tulsa, Okla., to succeed Mr. T. C. Hughes, resigned.

Mr. B. B. Kelliher, M. Can. Soc. C. E., Chief Engineer of the Grand Trunk Pacific Ry., has removed his headquarters from Montreal, Que., to Winnipeg, Man.

Mr. A. C. Fox, Contracting Manager of the National Bridge Works, has resigned that position to enter into partnership with Mr. W. E. Truesdell, civil and mill engineer, of New York City, under the firm name of the Truesdell-Fox Co., Engineers and Contractors, with offices at 7 West 38th St., New York City.

Mr. M. S. Ketchum, M. Am. Soc. C. E., Dean of the College of Engineering of the University of Colorado, has been granted a leave of absence for the next college year. During his absence, Professor Ketchum will be associated with Mr. H. S. Crocker, M. Am. Soc. C. E., consulting engineer, 811 17th St., Denver, Colo.

Mr. Perry Barker, recently Assistant Engineer, U. S. Geological Survey at the fuel-testing plants in St. Louis and Jamestown, has become Assistant Chemical Engineer in the fuel-testing department of the Arthur D. Little laboratory of engineering chemistry in Boston, Mass. Mr. Barker is a graduate of the course in chemical engineering at the University of Illinois.

Mr. W. H. Prescott, M. Inst. M. E., Assoc. M. Inst. C. E., Chief Engineer to the Tottenham (London) Urban District Council, has been recently called to the bar at Gray's Inn. Mr. Prescott is President of the Institute of Sanitary Engineers and a member of the Association of Water Engineers, the Royal Sanitary Institute and of the Incorporated Association of Municipal and County Engineers.

Obituary.

Newton J. Tharp, City Architect of San Francisco, Cal., died May 12 at the Knickerbocker Hotel in New York City. Mr. Tharp was born at Petaluma, Cal., in 1867. He became City Architect of San Francisco in October, 1907.

Henry H. Rogers, Vice-President of the Standard Oil Co., died May 19 at his residence in New York City. Mr. Rogers was President of the Virginia Ry. and of the Amalgamated Copper Co. and was connected as a director or executive with a number of other important corporations. He was born in 1840 at Fairhaven, Mass., and was educated in the schools of that village, graduating at the Fairhaven High School in 1856. After leaving school, he sold papers for a time in Fairhaven and New Bedford, but soon gave up this work to become a clerk in his father's grocery store, in Fairhaven, at three dollars a week and board. He continued in this position for five years and then, after a short interval in which he worked as a brakeman for the Fairhaven Branch R. R., he went to the Pennsylvania oil regions, where he remained about six years and obtained his foundation knowledge of the details of the oil business. He next entered the employ of the oil refinery controlled by Charles Pratt in Brooklyn, N. Y., and soon attained a place of prominence in the Pratt company, becoming with Mr. Pratt a trustee of the Standard Oil Co. at the time of its inception in 1874.

Engineering Societies.

COMING MEETINGS.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 25-27. Annual meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 1-4. Annual convention at Atlantic City, N. J. Secy., W. W. Freeman, 29 West 39th St., New York City.

AMERICAN WATER-WORKS ASSOCIATION.
June 7-12. Annual convention at Milwaukee, Wis. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 16-18. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 21-23. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
June 21-23. Annual meeting at Chicago, Ill. Secy., D. B. Sebastian, C. & E. I. R. R., 327 La Salle Station, Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 23-25. Annual meeting at Detroit, Mich. Secy., P. W. Drew, Wisconsin Central Ry., Chicago, Ill.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 24-26. Semi-annual meeting at New York City. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 24-26. Annual convention in New York and Brooklyn. Secy., Arthur L. Williston, Pratt Institute, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 28. Annual convention at Frontenac, N. Y. Secy., Ralph W. Pope, 33 West 39th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 29-July 3. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
July 5-9. Annual meeting at Seattle, Wash. Secy., A. H. Dimock, City Hall, Seattle, Wash.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
July 6-9. Annual convention at Bretton Woods, N. H. Secy., Chas. W. Hunt, 220 West 57th St., New York City.

OHIO ELECTRIC LIGHT ASSOCIATION.
July 13-15. Annual convention at Toledo, Ohio. Secy., D. L. Gaskill, Greenville, Ohio.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
July 15-16. Summer meeting at Indianapolis, Ind. Secy., W. M. Mackay, P. O. Box 1818, New York City.

INTERNATIONAL ASSOCIATION OF FIRE ENGINEERS.—The 17th annual convention will be held Aug. 17-20 in Grand Rapids, Mich. The secretary is James McFall, Roanoke, Va.

NEW YORK ELECTRICAL SOCIETY.—At the meeting to be held in New York City, May 27 a paper entitled "Practical Application of the Modern Electric Vehicle" will be presented by Mr. Day Baker.

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.—The fifth congress will be held in Copenhagen, Denmark, Sept. 7-11. The secretary is Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

NEW ENGLAND WATER WORKS ASSOCIATION.—In conjunction with the Boston Society of Civil Engineers, the members of this association will make an excursion May 21 and 22 to Springfield, Mass., to visit the work now under construction for the Water Department of the City of Springfield.

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—A party made up of members and their guests will make a visit of inspection June 5 to the plant of the Edison Portland Cement Co. at New Village, N. J.

At the regular meeting on May 26, Mr. Nicholas S. Hill, Jr., presented a paper on "Sanitary Protection of Public Water Supplies."

APPALACHIAN ENGINEERING ASSOCIATION.—At the meeting in Roanoke, Va., May 8, Mr. L. S. Randolph, M. Am. Soc. C. E., Professor of Mechanical Engineering at the Virginia Polytechnic Institute, read a paper on "Water Power Possibilities of the South." This paper discussed the maximum and minimum flow of streams and the computation of available water power, giving the results of several years of research.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.—At the regular meeting in Pittsburg, Pa., May 18, Mr. R. B. Woodworth, M. Am. Soc. C. E., presented a paper on "The Steel Beam." After reviewing the development of the steel beam, he took up the subject of present practice in beam design and discussed the beam as a structural unit. In treating of rolling efficiency in beam production and the relation of chemical and physical qualifications of steel, he presented the practical results of recent investigations on full-sized sections. Eleven tables were given in which were recorded the results of more than one hundred tests on full-sized standard and thin-web beam sections.

ENGINEERS' SOCIETY OF PENNSYLVANIA.—At the first convention of this society, which is to be held at Harrisburg, Pa., June 9-11, there will be 20 lectures on various subjects of interest to engineers. The list of subjects includes the following: Disposal of Sewage; Disposal of Manufactural Wastes; Home Disinfection by Ozone; Water Purification on a Large Scale; Concrete Bridges; Pavements; Explosives, with Particular Reference to Mine Disasters; Conservation of Resources; Forestry; Water Power Development; Low Pressure Turbines; Electric Furnaces. Most of these lectures will be given on June 10 and, on the evening of the same day, there will be an illustrated lecture on "The Panama Canal" by either Mr. Arthur P. Davis, M. Am. Soc. C. E., or Lieut.-Col. W. F. Hodges, Corps of Engineers. Excursions will be made June 11 to a number of points of interest in and near Harrisburg, including the Enola classification yards of the Pennsylvania R. R., the water filtration plants of Harrisburg and of Steelton, and the plant of the Pennsylvania Steel Co.

AMERICAN WATER WORKS ASSOCIATION.—The papers to be presented at the 29th annual convention in Milwaukee, Wis., June 7-12, will include the following:

June 8. Reports of committees on electrolysis, fire protection, water-works standards, depreciation and uniform annual accounts; "Valuation of Water Power and Diversion Damages," R. E. Horton; "Tests and Notes on Method of Operation of a Producer Gas Pumping Plant," J. R. Fitzpatrick; "Description of the Process and Plant of the Jersey City Water Supply Co., for Sterilization of Water at Boontown Reservoir," Geo. W. Fuller. In connection with the report of the committee on uniform annual accounts, papers will be read by Albert H. Wear and L. G. Powers.

June 9. "An Attempt to Annul a Perpetual Charter," J. R. Fitzpatrick; "Notes on Going Value and Methods for Its Computation," J. W. Alvord; "The Development of Water Supply at Superior, Wis., with Special Reference to the Iron Removal Plant," Wm. C. Lounsbury; "Coals for Hand-Fired Steam Plants," D. T. Randall; "The Use and Abuse of Fuels," H. M. Wilson; "Smoke and Smoke Prevention," L. P. Breckenridge and K. G. Smith.

June 10. "Buying Fuel by Test," E. W. Bemis and C. F. Shultz; "Chemical Data as Related to the Power Plant," S. W. Parr; "Water Supply and Treatment for Power-Plant Purposes," Wm. M. Booth; "Test of High Duty Pumping Engines With and Without Superheated Steam," John Primrose; "The Maidstone Epidemic," Wm. P. Mason; "The Sanitary Condition of the Southern End of Lake Michigan," J. H. Brewster.

June 11. "Municipal Ownership of Public Utilities," E. Maclean; "Concrete in Water Works Construction," Wm. C. Maybee.

June 12. "Meters and Meter Rates," Wm. Volkhardt; "Waste Water Surveys, Chicago," T. C. Phillips.

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